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U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS.

FIELD OPERATIONS OF THE BUREAU OF SOILS,

1904.

[SIXTH REPORT.]

BY

MILTON WHITNEY, Chief.

WITH

ACCOMPANYING PAPERS BY ASSISTANTS IN CHARGE OF FIELD PARTIES.

WASHINGTON:
GOVERNMENT PRINTING OFFICE.
1905.

[PUBLIC RESOLUTION—No. 9.]

JOINT RESOLUTION Amending public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, "providing for the printing annually of the report on field operations of the Division of Soils, Department of Agriculture."

Resolved by the Senate and House of Representatives of the United States of America in Congress assembled, That public resolution numbered eight, Fifty-sixth Congress, second session, approved February twenty-third, nineteen hundred and one, be amended by striking out all after the resolving clause and inserting in lieu thereof the following:

That there shall be printed ten thousand five hundred copies of the report on field operations of the Division of Soils, Department of Agriculture, of which one thousand five hundred copies shall be for the use of the Senate, three thousand copies for the use of the House of Representatives, and six thousand copies for the use of the Department of Agriculture: *Provided*, That in addition to the number of copies above provided for there shall be printed, as soon as the manuscript can be prepared, with the necessary maps and illustrations to accompany it, a report on each area surveyed, in the form of advance sheets, bound in paper covers, of which five hundred copies shall be for the use of each Senator from the State, two thousand copies for the use of each Representative for the Congressional district or districts in which the survey is made, and one thousand copies for the use of the Department of Agriculture.

Approved, March 14, 1904.

[On July 1, 1901, the Division of Soils was reorganized as the Bureau of Soils.]

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Albert G. Rice, *Chief Clerk.*
Charles H. Seaton, *Editor.*

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---

[a] Transferred to soil management.
[b] Resigned, 1905.
[c] Detailed to Cornell University.
[d] Transferred to Soil Fertility.
[e] Resigned, 1904.
[f] Transferred to Alkali Reclamation.

84277

LETTER OF TRANSMITTAL.

U. S. DEPARTMENT OF AGRICULTURE,
BUREAU OF SOILS,
Washington, D. C., November 13, 1905.

SIR: I have the honor to transmit herewith the manuscript report, with accompanying illustrations and maps, of the field operations of the Bureau of Soils in 1904, the publication of which is authorized by public resolution No. 9 of the Fifty-eighth Congress, second session.

Respectfully,

MILTON WHITNEY,
Chief of Bureau.

Hon. JAMES WILSON,
Secretary of Agriculture.

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FIELD OPERATIONS OF THE BUREAU OF SOILS.

1904.

By **MILTON WHITNEY**, Chief.

GENERAL REVIEW OF THE WORK.

THE OBJECT OF THE SOIL SURVEY.

The soil of the United States constitutes its greatest national asset. From the products of the soil are drawn the most numerous basal commodities of commerce and trade. For the cultivation of the soil, for the commerce and manufactures to which it leads, and for the housing of the people who till the soil, mines are worked and manufacturing industries are conducted. The soil is fundamental in its uses. For these reasons the study of the soil must always occupy a fundamental position in the development of the resources of the United States and in the arrangement of its economic conditions. Only within recent years has the great variety which actually exists in the soil resources of the United States been understood. Beginning in 1899, the soil survey of the Bureau of Soils has been engaged in the classification of soils, in the representation, upon soil maps, of the occurrence of the various types discovered, and in the preparation of reports which describe the characteristics and the uses of the different soils encountered. Since the beginning of this work, in 1899, approximately 100,000 square miles of the agricultural regions of the United States have been surveyed. Nearly 400 different types of soil have been encountered, and special studies have been made not only of the soils adapted to the growing of the cereal crops, but also of those special-purpose soils which have a high value for the production of fruit of various kinds, of truck, of market-garden crops, of the different varieties of tobacco, of sugar beets, and of many newly introduced crops.

It is the object of the soil survey to prepare maps which will indicate the extent, the distribution, and the location of the principal types of soil found in the United States. These are considered to be of equal importance with the various sources of fuel supply and the different kinds of ores, whose distribution and extent is carefully ascertained by all civilized governments. In addition to the fundamental work which concerns the area and distribution of the soils, there is based upon this a careful study of such particularly important problems as the best adaptation of crop to soil, the best method of maintaining or restoring soil fertility, the proper ways for redeeming land threatened by the accumulation of alkali, and the general study of the soil and crop resources of the entire country.

The areas which had been mapped by July 1, 1905, were distributed among forty-three States and Territories. The total extent of the survey amounted to 99,408 square miles, or 63,621,120 acres. The surveys have been so distributed that nearly every prominent agricultural interest has been touched, and the soils of some part of every important agricultural region have been studied. Aside from the specific problems which affect individual areas, there have been developed a number of vital problems which concern wide extents of agricultural land. Thus studies made in New York and northern Ohio and Indiana, southern Michigan, and southern Wisconsin have made possible the generalization that certain classes of soils in these localities are especially adapted to the production of sugar beets under the climatic conditions which exist. It is possible to state at the present time that within the area surveyed throughout this general region the heavier loams, well supplied with partially decomposed organic matter and so situated as to maintain an adequate moisture supply, constitute the best beet soils of the Northeastern States.

Similar studies along the Atlantic seaboard have demonstrated that the Norfolk sand, Norfolk fine sand, and the Norfolk fine sandy loam are peculiarly adapted to the production of those early vegetables and fruits which furnish the supply for the northern city markets. It has also been shown in this connection that where transportation is adequate, land belonging to these three soil types which formerly had a value of $5 an acre can readily be made to have a value of from $100 to $200 an acre for the production of the truck crops.

It has been shown that the preeminence of the Central States in corn production is largely due to the wide extent and general distribution of three types of soil—the Maimi black clay loam, the Marshall loam, and the Marshall silt loam, which are peculiarly adapted to corn production under the climatic conditions of that region.

It has also been shown that in the region of the Great Lakes, from northern Ohio eastward to central New York, certain types of soils belonging to the Dunkirk series are especially well adapted to the production of table grapes, and several areas have been mapped which serve in a general way to outline the localities where these soils occur.

The recent importance of the rice industry in Louisiana and Texas has led to investigations of the soils best adapted for growing this crop. It has been found that in general the heavy silt loams and clay loams of the Louisiana and Texas seacoast prairies are well adapted to rice production, and it has been upon soils of this character that the wonderful strides in rice production have been made possible.

The production of apples in the United States has appeared to be shifting from the older localities to more recently developed regions. While the bulk of the crop is still produced in New York, Pennsylvania, and Ohio under conditions which have been known for a long period of years, still the increasing importance of the Illinois, Missouri, and Arkansas fruit regions has rendered necessary a study of the soil types which in actual practice have given the best results in apple culture. Such surveys as would record the observed facts have been made in these localities, particularly in Clay and Clinton counties, Ill., and in Howell and Webster counties, Mo. The great development of the pippin industry along the eastern chains of the Allegheny Mountains has also required careful examination of the soils and climatic conditions of the belt in which pippins can be grown most successfully, and the soil type (the Porters black loam) upon which the trees thrive best has been outlined by the soil surveys made in Maryland, Virginia, and North Carolina.

The changes from extensive to intensive farming which are necessitated by the movements of population during the past two decades in the United States require careful study of the agricultural possibilities within the older settled regions. It is no longer possible for the Eastern and Northeastern States to compete in cereal production with the central and northwestern prairies. The abandonment of the older systems of grass and grain farming has become imperative. In order to replace the former system by others which are adapted to modern economic conditions and at the same time to the soils and climate of the older States, it is necessary to make a careful study of the soils of these regions and of their adaptation to various crops which may take the place of the small grains and of grass. Work along this line has been begun in New England and in New York. The solution of the problems involved can only be secured by the people themselves concerned, but in order that they may be insured against wasteful experimentation and large pecuniary loss it is necessary that first of all they should be made aware of the soil resources of their communities. Not only are soil surveys of such regions necessary, but the work of the Bureau in the study of the profound problems of soil fertility and of soil management is also essential.

In the arid regions the soil survey has carried on extensive work in the study not only of the soils and of their adaptation to special crops under various conditions, but it has also made an especial effort to study the characteristics of alkali, the causes of its accumulation, and the methods which must be used for the prevention of its accumulation and for its removal where it is already prevalent. In this work the soil survey makes not only a soil map, but also an alkali map, showing the amounts, the character, and the distribution of the various soluble salts which interfere with plant growth. The alkali map thus prepared is used by the Bureau as a basis for further work along the line of alkali reclamation, and maps of this character have also been prepared at the request of the U. S. Geological Survey for the use of the Hydrographic Division, which has charge of the Government work in connection with the irrigation of arid lands.

The work of the Bureau of Soils has been particularly effective in connection with the study of the tobacco crop of the United States. It has been shown by the work of the soil survey that the characteristics of the tobacco leaf produced depend to a great extent upon the character of the soil upon which the crop is grown. For example, the fine, silky, flexible leaf desired for use in wrapping cigars is produced to the best advantage upon soils of a sandy character. The bright tobaccos of Virginia and the Carolinas are best produced upon soils which have a sandy surface and a heavier sandy loam or loam subsoil. The heavy, gummy, plug-filler tobaccos are produced upon the stiffest clays and the heaviest loams. Thus the character of the soil largely influences the kind of tobacco which can be grown to advantage in any given area. Following these discoveries, the Division of Tobacco Investigations of the Bureau of Soils has carried on a large amount of work in studying the cultural methods, the character of fertilizer, and the methods of curing and marketing the tobacco crop. All of this work has its foundation in the soil surveys which have preceded it. The generalizations which made a considerable part of this work possible have been reached by careful study of the soils in many widely separated tobacco-producing districts.

CLASSIFICATION OF SOILS.

The classification of the soils of the United States must take into consideration both the relationship existing between soils of limited areas and those which concern the entire county. Thus while a classification founded chiefly upon texture and upon local conditions may be satisfactory over limited areas, the general classification must rest upon a basis of geological origin, of method of formation, and of topographic similarity.

In making the field classification there are four main groups of factors which are found to occupy a position of special prominence. The first of these is soil texture, by which is meant the relative proportion of solid soil grains of various sizes found in any particular soil. Upon this basis of texture the soils are classed as sands, sandy loams, loams, or clays, depending upon whether they contain a large proportion of coarse or of fine particles. This textural peculiarity of soils influences crop growth through its direct effect upon the drainage of soils, upon their ability to maintain moisture throughout the growing season, upon their aeration, and upon the ease or difficulty with which they may be tilled. The texture of a soil is determined by mechanical analysis, through which the soils are separated into their component parts of the various grades of sand, silt, and clay, and this mechanical analysis of the soil expresses the various proportions of these separates which are found in each soil. The mechanical analysis affords a basis for texture comparisons between soils, although it constitutes but one factor in their correlation.

The second point which is taken into consideration is the structure of the soil—that is, the arrangement in space or the condition of aggregation of the soil particles. It is found in the field that two soils which may give approximately the same mechanical analysis may have markedly different characteristics, peculiarities of drainage, aeration, moisture-holding power, and ease of cultivation, because of the form in which the solid particles of the soil are bound together. With some soils the coarse and fine particles are thoroughly intermixed, making a homogeneous, compact mass. In such soils the structure is said to be massive. In other soils the finer particles, such as silt and clay, are found to adhere to each other, forming a granular mass, or else they are more or less adherent to the surfaces of the larger sand particles which are scattered through the mass. Such a soil is said to be granular, and where this characteristic is most fully developed, as in the case of numerous level bottom-land soils, the expressive local name "buckshot land" is frequently applied. Again, other soils which under normal conditions are nearly homogeneous and massive become cracked and checked through the loss of moisture by evaporation, which results in a sun-cracked or jointed structure. In this way the state of aggregation or structure of the soils must be taken into account in making any classification which is based upon the physical properties of the soil. The soil structure exerts a marked influence on soil drainage and soil aeration, because it modifies the permeability of the soil to both water and air.

Thus far the points of classification considered have been those which concern chiefly the solid mineral particles found in soils. It is frequently the case that the organic matter existing in the great majority of soils plays a very important part in determining the physical properties of the soil, so that the classification must take into account not only the amount of organic matter found, but also its condition, whether coarse or fine, partially decayed or freshly formed, and to some extent its distribution, whether the manifest portion is all found in the surface few inches or is thoroughly mingled with the soil mass to a considerable depth.

The texture, structure, and organic matter content of the soil concern the characteristics of the soil body itself, and are nearly as pronounced in the isolated sample as in the mass of the soil under field conditions. There are, however, soil characteristics which are dependent upon the location, the altitude, the surface configuration, and the relationship of the soil body to other surrounding materials. These peculiarities of soil are grouped under the general term of its physiographic relationship. Among these relationships the surface topography, which controls the surface drainage of the soil, is one of the most important. Another important feature is the depth of the soil material to impervious clays or to underlying rock. Still a third is the nature of the soil surface, whether rough and stony or level and free from stones. In the same way the attitude of the surface, whether level, rolling, hilly, or mountainous, must be taken into consideration. All of these groups of soil characteristics are taken into consideration in the classification and naming of the soil type.

On the basis of soil texture, the soils are named sands, sandy loams, loams, silt loams, clays, or whatever else the facts may warrant. This grouping is known as the soil class. It is found in the field that there may be a great variety of loams or sandy loams, all of which are very similar in texture, but each of which differs from the others to a marked degree, either in structure or the amount and condition of the organic matter, in origin, or even in physiographic relationships. As a result it is necessary to distinguish within the soil class, as among the loams or clays, those which have different peculiarities other than characteristics of texture. This distinction is made through the use of a local name. One loam may be called the Miami loam, after the locality where it was first mapped; another, the Norfolk loam; still another, the Yazoo loam, and so on in every case of distinctive soils of this class.

The local name is now used not only to express the fact of differences between soils of the same class, but it is also found that there are certain relationships between soils which should be expressed in their nomenclature. Thus, while a certain series of geological occurrences has been in progress, soil material has been separated out into a sandy portion, a gravelly portion, and others of loamy or clayey character. Wherever there is a general relationship between these different classes of soils, due either to their geological origin, their method of formation, or their location within an area, a common, distinctive locality name is used, and the soils thus grouped together are called a soil series. Thus in the glaciated region of the United States north of the Ohio River there occurs an extensive series of soils known as the Miami series. The different types within this series are called, respectively, the Miami stony loam, Miami gravelly loam, Miami sandy loam, and so on down to the Miami clay loam, the finest-textured soil of the series. Similarly, along the Atlantic coast there is a particular series of marine deposits which have been classed as the Norfolk series of soils. This series also contains a gravelly member, a sandy member, and so on down to a clay. In this way the name of a soil is intended to express at the same time its texture and physical properties in the latter or descriptive part of the name, and something of its locality and geneological origin through the series relationship expressed in the locality name which precedes the descriptive name. In this matter the common scientific usage of geological science and of botanical and other biological sciences is modified for application to the soil classification.

In the classification employed by the Bureau of Soils the aim is to secure a simple, general system, which shall express those facts with regard to soils which are easily recognizable by a person possessing ordinary powers of observation and no unusual knowledge either of classifications or of soils. For this purpose the common names of soils used by the general agricultural public are adopted and defined for use in the Soil Survey reports. Owing to the fact that in different localities soils of the same texture will receive slightly different names, it has been found necessary to define rather carefully what is meant by a clay, a loam, or a sand. Thus, in regions where the heavy clay or clay loam soils predominate a somewhat sandy soil is very often considered to be a real sand, while if it were compared with the soils of a sandy locality it would be considered and would be spoken of as a rather heavy loam. Through the use of its standard method of mechanical analysis, which determines the amounts of the different-sized particles found in a soil, the Bureau aims to eliminate these local differences in soil naming, in order that a uniform standard, such as may be used both for scientific and practical purposes, may become common throughout the regions where surveys are made. The naming of the soils is not intended to introduce confusion, but rather to avoid the use of local designations which may mean one thing in one place and another thing in a different place.

CROP ADAPTATION OF SOILS.

About 400 different types of soil have been encountered by the Soil Survey since the beginning of its field work in 1899. These soil types have been studied and classified with a view to ascertaining the particular crops which each type is best suited to produce. They have also been studied from the double standpoint of meeting the local needs and of placing the particular type not only in its true relationships to the area in which it occurs, but also in its proper place in the general classification of the soils of the United States. Holding these two objects in view, the study of the soils through the field work is coming to have two primary objects. The first of these, the discovery of the best crops for each soil, is known as crop adaptation. The second, or the study of the method by which each soil may be induced to grow the largest economical crop, is known as the soil fertility or the soil management problem. In addition, various local problems are encountered in nearly every area. It is a notable fact that, while the soils of the United States vary between wide extremes, only a few standard staple crops are produced upon all of them even under the most diverse climatic conditions. As knowledge of the soils of the United States increases and becomes more general, it is easily seen that the farmers are not securing the best possible results from their agricultural pursuits through a lack of knowledge of the intimate relation between crop and soil which is comprehended in the term "crop adaptation." Wheat is grown in all latitudes, from Texas to the Canadian line, upon soils of widely varying texture. From some of these soils the crop returns are satisfactory; upon many of them wheat is produced either with a small margin of profit or at an actual loss. It is not to be supposed that a wheat soil in Texas or Alabama and a wheat soil in Minnesota must necessarily have the same characteristics. Quite the reverse should be anticipated, since the ability of a given piece of land to produce wheat or any other crop depends largely upon a nice balancing of the physical properties of the soil against the climatic conditions which surround it, and a soil, which in a humid and cool region is suited to produce large yields of wheat, under conditions of scanty rainfall and considerable heat would be found of low value for wheat production. This fact applies to nearly every one of the great staple crops of the country, and the object of the Soil Survey is to secure such a large amount of information regarding this delicate balance between soil peculiarities and climatic characteristics that it may be possible to guide not only the individual farmer, but entire communities in the selection of the crops best adapted to their local conditions.

In some instances it has been found that a crop which is produced with little profit under the existing climatic and soil conditions and under the method of culture followed in the region may be produced, under the same natural conditions, to good advantage by adopting such changed agricultural methods as will serve to strike a balance between the soil conditions and the climatic conditions. The Soil Survey is at all times gathering information in regard to the cultural methods employed in areas where a soil survey is made, and information on this subject is included in the published report under the titles "Agricultural conditions" and "Agricultural methods."

Similarly, the market demands and the location with regard to market outlets exert a strong influence upon the character of crop which may be grown, even when a wide range of crops is possible under the soil and climatic conditions found to exist. For this reason the Soil Survey reports contain an account of the transportation facilities and the market demands of the region surveyed.

In the same way it is becoming more and more evident that the introduction and production of some of the staple crops, especially those not directly devoted to furnishing a food supply, is controlled by accident rather than by system. Thus the highly specialized crop of tobacco is frequently introduced into a new region through the advent of some newcomer who has learned farming in a tobacco-growing district. This person, or sometimes a group of persons, finding the soil and climate similar to those of the old home locality, commences to grow tobacco, and his neighbors, if they learn that he is deriving a profit from the new crop, learn the methods of culture and of curing from him, and thus a new tobacco-producing center is created. This is the story of a number of the northern tobacco-producing areas, and is illustrative of the accidental method by which new crops are frequently introduced. It is the aim of the Soil Survey to gather such information as may be of use to the various portions of the United States in the speedy and profitable introduction of crops well suited to their community, with which the people may at present be unacquainted, although the crop would be likely to prove of greater profit than any grown there at present.

During the past few years new crops have been introduced, not only from one part of the United States to another, but also into the United States from a large number of foreign countries. In order that this introduction of new crops may take place with the least expense to the persons and communities interested, it is essential that the soil and climatic conditions of the region to which the crop is to be introduced should be well known, so that comparison may be made with the same features of the region from which it is introduced. This study of the United States as a possible field for the production of practically every crop which the people may desire either to produce or to consume is one of the most important features of the Soil Survey work.

The people of the United States are provided in each State and Territory with at least one agricultural college and experiment station where scientific research along agricultural lines is carried on, and where information is imparted to the younger members of the community. A vast amount of scientific agricultural work has been accomplished by these colleges and experiment stations. In the nature of the case, however, it is frequently impossible for the agricultural experiments to be conducted at more than one or two places within the State. Experiments conducted in a limited area and upon a few soil types are occasionally not of general application throughout the State whose interests are to be served. In order that the vast amount of valuable information which has been secured by these experiment stations may be made of the most direct application to each farming community within the State served, it is necessary for the farmer to know not only the details of any particular experiment, but also for him to be able to judge whether his own farm contains the types of soil upon which the experiment has been carried on, and whether it lies within the same general climatic belt as the experiment station itself. If he can be assured of these two facts, it is then possible for him to derive the greatest benefit from the results of any particular experiment. If he can not be assured of these facts, it remains for him to discover whether the conditions under which he is working are the same as those which are found at the experiment station. The Soil Survey is thus seen to serve not only a local purpose of this kind, but through its general classification of the soils of extensive regions it has frequently occurred that the results secured at a given experiment station become applicable not only with the limits of that State, but are also found to be applicable in other adjoining States, or throughout a considerable region. It thus renders the results of experiments conducted at the various experiment stations applicable throughout a wide range of territory not restricted by State lines.

THE USES OF THE SOIL SURVEY.

The soil survey is meeting with increasingly gratifying evidences of the extent to which the soil maps are being used by the various interests for whose benefit they are made. A careful check list is kept of the demand for advance sheets of each area. An inspection of this list covering the areas reported upon to July 1, 1905, shows that a great variety of interests are concerned with the results of the survey work. The number of requests for advance sheets is steadily increasing, and 40,000 separates have been distributed from the Bureau's office alone to meet the demand for the reports made in 1902 and 1903. The sources of these demands are distributed with remarkable uniformity all over the United States. Maps of the truck regions along the Atlantic seaboard and of the fruit regions of the Northeastern States are in particular demand at the present time. Thus large numbers of requests for the soil surveys of the Lyons area, New York, the Long Island area, New York, and McLean County, Ill., have been distributed in response to direct applications. This distribution is in addition to the distribution made by the Senators and Representatives in whose States or districts the surveys were made.

The surveys made in the interest of the new tobacco industry in eastern Texas have also met with a wide demand, particularly in the case of the Woodville, Paris, Jacksonville, and Lufkin areas. The majority of these reports go into the hands of individual farmers, who are anxious to learn whether any of the soil types adapted to the production of this new tobacco are to be found upon their farms.

A large number of the soil survey reports concerning the trucking areas are distributed not only within the trucking areas themselves, but throughout the West and Northwest, to people who are desirous of settling in these trucking areas and engaging in intensive farming upon a small scale. A similar demand exists for the surveys made in the principal fruit regions of New York, Virginia, southern and central Illinois, and in Missouri and Arkansas.

In addition to the reports sent to individuals, which usually convey information to a single person or to a small group, a large number of reports are annually asked for by real estate and investment companies, who use these reports to furnish accurate and unprejudiced information of the regions in which their farming lands may be located. On several occasions requests from real-estate men have been accompanied by the statement that their customers will not purchase land until they have been shown the location upon the soil maps of the farms which are offered for sale. The unprejudiced nature of the information given by the reports is thus clearly recognized, not only by the purchasers of land, but also by the agent and by the persons having land for sale.

Considerable use is being made by the general public of reports covering areas recently opened for settlement. The new settlers or prospective purchasers desire to know the climatic conditions, peculiarities of soil, and character of crops best suited to the region, and the kind of farming in which they can engage most profitably. The value of these reports is beginning to be recognized not only by the individual settler but also by the persons or companies having land for sale in such newly developed regions.

The use of the reports is particularly necessary in the irrigated regions, where the settler must take into account not only those characteristics of soil and climate of which he himself may be competent to judge, but must also consider the presence and the amount of alkali, of which in many cases he is totally unable to form an accurate opinion. As these reports in the arid regions cover not only the soil and crop conditions, but also the questions of the supply of proper irrigation waters, the presence and distribution of alkali, and even the methods for the economical distribution of water, they are being used to an increasing extent in the development of the newer regions of the United States.

Another important use of the soil-survey reports which is being developed at present through the increasing extent of the total areas covered within the United States is that made by investment companies, who desire information not only regarding particular plots of ground, but who also desire an account in general terms which will give them an insight into the agricultural characteristics of entire counties or, in some cases, of contiguous portions of several States. The proper investment of the funds intrusted to these companies demands a knowledge not only of the peculiarities of soil and climate, but also of the broader features of transportation, market facilities, and the general prosperity of the agricultural community. One of the principal demands for the complete sets of the annual reports comes from such sources.

Within the last few years a demand for soil-survey reports which shall cover not a single area, but the characteristics of entire regions, has arisen. This is particularly marked in the case of the development of different branches of tobacco production in the Gulf States, in the Northern Atlantic States, and in the Northern Central States. Similarly a demand has arisen for the study of the characteristic properties of sugar-beet soils throughout the sugar-beet belt of the humid region. These two are merely samples of the new form of inquiry which the soil-survey investigations must meet.

It is no longer sufficient to know that a certain soil in a certain county is adapted to the production of tobacco, or sugar beets, or truck crops, or to various forms of fruit. After an area has been mapped which shows that a certain type of soil or a certain group of soils under given climatic conditions is peculiarly adapted to any high-priced and profitable crop, and as soon as such a fact becomes generally known there is immediately aroused a considerable demand for the extension of surveys along such lines that they shall indicate the limits of the conditions under which the particular crop can be grown.

Again, it is frequently not sufficient to indicate the soil and climatic factors alone in the introduction of new crops, but following the soil survey work it becomes necessary for the Bureau, under its appropriations for tobacco investigations, alkali reclamation, soil fertility study, or soil management work, to follow up the preliminary survey work by actual demonstration of indicated results, so that the points brought out in the reports may be clearly shown in all their details to the persons directly affected by the inquiry. For this reason the soil survey work in the arid regions has been followed in several instances by a demonstration of alkali reclamation methods devised and put into execution by the Bureau experts. Similarly, the discovery that high grades of cigar-filler tobacco could be produced in certain of the Gulf Coast States led to a call for the demonstration not alone of this fact, but also of the methods by which the crop could be grown, cured, and marketed. This condition arose because the tobacco crop was an unfamiliar product to the farmers of the region, and they must learn the details of its production in order to make use of the information previously placed in their hands through the medium of the soil survey reports.

In the same way extensive studies throughout the Eastern and Northeastern States have shown that many of the so-called "worn-out" soils are not failing to produce satisfactory crops because of any essential deficiency, but that the occasional low producing power of certain areas is due to unwise systems of cropping and of crop rotation and to a failure properly to adapt the crop to the soil and to the climate. The production of cereal crops upon these soils was still essential under agricultural conditions existing from thirty to fifty years ago. Under more recent agricultural conditions now prevailing in the United States, particularly those giving rise to the extensive production of cereal crops upon the prairie lands of the Central and Northwestern States, grain production is no longer profitable in many of the older States. Thus a considerable portion of the country is concerned with the problem of changing its agricultural practice slowly and along conservative lines, so that soils which no longer give a profit for cultivation to the grain crops may be made profitable under more intensive conditions of agricultural production—that is, those food crops which must be produced in close proximity to the markets where they are sold are seen to be the ones which should engage the attention of the majority of the farmers in the older States, and the introduction of new crops and new methods to suit these new conditions constitutes one of the strongest reasons for making surveys which shall give the characteristic crop adaptation of the soils of this general region.

Similarly, the movement of large manufacturing establishments from the older manufacturing centers to new localities has given rise to the necessity for the production of food products in regions which before had been devoted to the production of one or more of the staple crops. The enormous increase in the milling operations of the Southeastern States has given rise to the development of considerable centers, the population of which was formerly engaged in agricultural production, but which now must be fed by others who remain on the farm. Thus there is an increasing demand for vegetables, for dairy products, and for various other food products throughout the Atlantic seaboard States.

All of these problems, which are coming to be recognized in the modern development of American city life, as well as of American agricultural practice, require for their proper solution not only an accurate knowledge of the soil conditions, which must form the basis for changes in agricultural practice, but they require also a thorough demonstration of this knowledge when it is once obtained, in order that costly and needless experiments may be avoided and that the people most concerned may be led easily and directly to the necessary readjustment of economic conditions.

A consideration of the character and the scope of the soil survey reports will indicate that through these detailed studies of the soil resources, the climatic possibilities, and the agricultural needs of the various communities, much can be learned concerning the lines along which the agricultural development of many sections should be directed during the next few years. It is the chief purpose of the soil survey to record these facts. From these facts the special student and the general public may draw such conclusions as fit their individual cases, and as will be applicable to their individual needs.

PROGRESS AND COST OF SOIL SURVEY.

During the year the requests for additional soil-survey work have become more numerous and more urgent than ever before. At the same time the work of the survey has developed to such a point that many additional areas, some of them not covered by specific requests, must be mapped in order to secure the information requisite to the proper classification and correlation of the soils of the United States.

To secure economy of service under these conditions it has become necessary to map larger single areas rather than a greater number of small areas. By this means the item of cost of transportation between areas can be reduced to a small proportion of the entire expenditure, and at the same time an increase in efficiency of the parties is secured. This arises from the fact that the preliminary examination of each area to secure a general view of the prominent facts it comprehends and their relationships to the general classification occupies from one to two weeks. By reducing the number or areas and increasing their size a greater proportion of the time can be devoted to actual field mapping.

This slight change in the method of handling the parties has decreased the number of areas surveyed from 61 in 1903 to 48 in 1904, but in the same time the increase in total area has amounted to 1,901 square miles. The average size of the areas surveyed has increased from 435 square miles in 1903 to 593 in 1904.

At the close of the calendar year 1903 there had been surveyed 60,411 square miles, or 38,663,040 acres. During the calendar year of 1904 there has been mapped a total area of 28,444 square miles, or 18,204,160 acres. This gives a total of 88,855 square miles, or 56,867,200 acres, surveyed between the beginning of the work in 1899 and December 31, 1904. The different soil surveys have been distributed so that 43 States and Territories have received attention. In addition, at least some examination has been made of all of the chief soil and crop subdivisions of the United States.

The following tables show the States and Territories in which work has been done in 1904, the names of the areas surveyed, their extent, the cost per square mile, and the total cost of the field work in each area:

Areas surveyed and mapped and cost of field work, January 1 to December, 1904.

State or Territory.	Area.	Area surveyed.	Cost per square mile.	Total cost.
		Sq. miles.		
Alabama	Blount County	338	$4.40	$1,487.20
	Lauderdale County	315	2.46	774.90
	Macon County	621	1.60	995.20
	Montgomery County	338	2.34	790.92
	Sumter County	893	2.98	2,661.20
Arizona	Yuma	[a] 203	11.41	2,314.20
California	Bakersfield	195	9.91	1,932.48
	Sacramento	[a] 409	6.13	2,508.54
	San Bernardino	755	2.51	1,897.00
	Stockton	87	6.56	570.72
	Yuma	38	11.41	435.21
Colorado	Greeley	687	2.56	1,760.22
Florida	Gainesville	485	1.75	850.00
Georgia	Bainbridge	364	2.73	996.45
	Dodge County	489	1.98	968.59
Illinois	O'Fallon	68	1.19	80.92
Indiana	Boonville	264	1.77	467.10
	Marshall County	445	1.71	762.93
	Scott County	197	1.96	385.70
Iowa	Tama County	720	1.26	910.49
Kansas	Allen	504	1.72	868.68
	Brown County	378	1.84	695.52
	Garden City	335	2.04	681.86
Kentucky	Warren County	533	1.37	731.90
Louisiana	De Soto Parish	825	3.31	2,728.24
	Tangipahoa Parish	228	2.73	622.44
Michigan	Alma	282	2.30	648.00
	Munising	407	2.28	928.00
	Owosso	270	2.73	736.92
	Saginaw	984	2.08	2,046.00
Minnesota	Superior	23	1.70	39.40

[a] These figures do not include sections of these areas surveyed in preceding years.

Area surveyed and mapped and cost of field work, etc.—Continued.

State or Territory.	Area.	Area surveyed.	Cost per square mile.	Total cost.
		Sq. miles.		
Mississippi	Biloxi	615	$2.77	$1,704.00
	Jackson	737	1.25	921.60
Missouri	O'Fallon	552	1.19	656.28
	Saline County	748	1.18	885.40
	Webster County	605	2.12	1,285.20
Nebraska	Kearney	792	1.63	1,292.37
New York	Auburn	461	4.14	1,910.00
	Dryden	315	1.96	617.40
	Vergennes	160	2.33	372.80
North Carolina	Duplin County	340	2.76	938.40
	Perquimans and Pasquotank	215	4.42	950.30
North Dakota	Cando	283	4.53	[a] 1,283.00
Ohio	Coshocton County	551	1.38	761.60
	Wooster County	469	2.16	1,015.00
Pennsylvania	Adams County	534	1.80	959.90
Rhode Island	State	1.085	1.52	1,654.20
South Carolina	Charleston	352	3.25	1,144.00
	Lancaster County	486	1.90	923.21
	Orangeburg	[b] 479	2.87	1,375.00
Tennessee	Greeneville	664	1.26	838.40
	Lawrence County	618	2.44	1,506.00
Texas	Anderson County	1,069	2.22	2,369.71
	Austin	705	1.27	910.98
	Houston County	430	2.62	1,126.60
	San Antonio	484	2.17	1,051.92
Utah	Bear River Valley	334	5.36	1,789.44
Vermont	Vergennes	227	2.33	528.91
Virginia	Appomattox County	340	2.43	827.37
	York Neck	655	3.68	2,412.50
Wisconsin	Superior	459	1.70	780.60
Total		28,444	2.43	69,069.02

[a] Of this amount $300 was paid by the Economic Agricultural and Geological Survey of North Dakota.

[b] These figures do not include sections of these areas surveyed in preceding years.

Areas surveyed during the year ending December 31, 1904, and areas previously reported.

State or Territory.	Work during 1904.	Work previously reported.	Total.	
	Sq. miles.	*Sq. miles.*	*Sq. miles.*	*Acres.*
Alabama	2,505	2,238	4,743	3,035,520
Arizona	203	656	859	549,760
Arkansas		877	877	561,280
California	1,484	4,678	6,162	3,943,680
Colorado	687	1,573	2,260	1,446,400
Connecticut		505	505	323,200
Delaware		314	314	200,900
Florida	485	548	1,033	661,120
Georgia	853	757	1,610	1,030,400
Idaho		1,135	1,135	726,400
Illinois	68	5,853	5,921	3,789,440

Areas surveyed during the year ending December 31, 1904, etc.—Continued.

State or Territory.	Work during 1904.	Work previously reported.	Total.	
	Sq. miles.	*Sq. miles.*	*Sq. miles.*	*Acres.*
Indiana	906	822	1,728	1,106,920
Iowa	720	1,583	2,303	1,473,920
Kansas	1,217	1,133	2,350	1,504,000
Kentucky	533	866	1,399	895,360
Louisiana	1,053	1,853	2,906	1,859,840
Maryland		2,610	2,610	1,670,400
Massachusetts		809	809	517,760
Michigan	1,943	1,135	3,078	1,969,920
Minnesota	23	233	256	163,840
Mississippi	1,352	1,317	2,669	1,708,160
Missouri	1,905	1,430	3,335	2,134,400
Montana		107	107	68,480
Nebraska	792	769	1,561	999,040
New Jersey		1,303	1,303	833,920
New Mexico		129	129	82,560
New York	936	2,259	3,195	2,044,800
North Carolina	555	5,282	5,837	3,735,680
North Dakota	283	1,216	1,499	959,360
Ohio	1,020	1,695	2,715	1,737,600
Oregon		442	442	282,880
Pennsylvania	534	1,216	1,750	1,120,000
Porto Rico		330	330	211,200
Rhode Island	1,085		1,085	694,400
South Carolina	1,317	2,350	3,667	2,346,880
South Dakota		484	484	309,760
Tennessee	1,282	1,488	2,770	1,772,800
Texas	2,688	2,281	4,969	3,180,160
Utah	334	1,167	1,501	960,640
Vermont	227		227	145,280
Virginia	995	3,194	4,189	2,680,960
Washington		510	510	326,400
Wisconsin	459	955	1,414	904,960
Wyoming		309	309	197,760
Total	28,444	60,411	88,855	56,867,200

The work in the Yuma area was done at the request of the Irrigation and Reclamation Service of the U. S. Geological Survey to furnish a basis for the rating of lands in the districts which are to be irrigated and reclaimed. Data in regard to the character of soil, the amount of alkali, and the estimated cost of leveling the surface for irrigation of each 40 acres separately were secured, and this accounts for the high rate of cost of this area as compared with the others.

After taking into consideration the salaries of the men while actually in the field, their subsistence and transportation while in the area, but not including transportation to and from the area, the average cost of the field work has amounted to approximately $2.43 per square mile.

COOPERATION WITH OTHER ORGANIZATIONS.

The Soil Survey in its work in the different States aims to serve the local interests in every case where this is possible, through consultation with the State experiment stations, with the agricultural colleges, and, in some cases, with the State agricultural and geological surveys. Cooperation exists or has existed in this way in many of the States, and the relationships between the local organizations and the Soil Survey have been very pleasant. In some instances the cooperation has only existed to the extent of securing advice from the State authorities in regard to the problems encountered in the State, or concerning the areas which it might be best to survey. In other cases financial cooperation has existed. In all cases where cooperation of any kind has been entered into the maps and surveys published have borne not only the name and title of the Federal organization, but also the title of the State organization and the name of the officer in charge.

CHANGES IN THE FIELD SERVICE.

During the field season of 1904 the Bureau of Soils maintained 20 parties of two men each upon the field work. Since that time the Soil Survey has lost by transfer, resignation, or special assignment 12 of the members of its field force, without any corresponding replenishment from outside sources. The conduct of the investigations in soil fertility, in soil management, and in alkali reclamation has required the use of men who have had considerable field experience, in order that the problems presented as the result of the field work may be solved in the various localities concerned. It has been necessary under these circumstances to transfer field men, usually with a high degree of training, to these other branches of work in order that their knowledge may be employed in the solution of problems which, in many instances, they themselves have encountered or even outlined in their field work. In addition, the establishment of the reclamation work of the Bureau of Hydrography of the United States Geological Survey has served to create a demand for men skilled in the recognition of alkali and in the ability to plan and execute methods for irrigation under the Government storage reservoir act. Several men have thus been transferred to the Bureau of Hydrography. One man has been transferred to the soil service of the Philippine government. Several resignations have occurred on the part of men who have met with better financial offers from various commercial enterprises than the Soil Survey could afford. In these ways the Soil Survey force has been somewhat depleted.

SOIL SURVEY OF RHODE ISLAND.

By F. E. BONSTEEL and E. P. CARR.

LOCATION AND BOUNDARIES OF THE AREA.

The State of Rhode Island is included between the parallels of 41° 20′ and 42° north latitude and the meridians of 71° 10′ and 71° 50′ west longitude, approximately, with the exception of Block Island, which lies about 10 miles off the coast in the Atlantic Ocean. Rhode Island is one of the thirteen original States, and the smallest in the Union, comprising a land surface of 1,085 square miles, with a coast line of 400 miles. It is bounded on the north and east by Massachusetts, on the south by the Atlantic Ocean, and on the west by Connecticut. Its greatest length is 48 miles, and its greatest width 37 miles.

The State is divided into five counties, consisting of 38 townships, and contains four cities, of which the largest is Providence, the State capital, with a population of 176,000. The other cities are Pawtucket, Woonsocket, and Newport.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Rhode Island was settled in 1636 by Roger Williams, who had been banished from the orthodox Puritan colony of Massachusetts Bay on account of his ardent advocacy of liberty in religious beliefs. He settled at "Providence Plantations," near the present site of Providence, and two years later a band of Antinomians, also banished from Massachusetts Bay, settled at Portsmouth. Newport and Warwick were founded soon after, Newport by a secession from the Portsmouth colony and Warwick by still other dissenters from Puritanism. Each of these four towns was at first independent, and had radical ideas of its individual importance. Quakers and Baptists who had been persecuted and driven from Massachusetts were welcomed at these settlements, so that the earliest colonists of Rhode Island were largely religious freethinkers and dissenters from the rigor of Puritan orthodoxy.

In 1644 Roger Williams secured from Parliament a patent uniting the four towns under one government, but so pronounced was the feeling of local independence that it was not until 1647 that a common fear of the encroachments of Massachusetts and the danger of multiplying internal revolts made the union effective. In 1663 a charter was obtained from Charles II, which served as a constitution until 1843, when the present State constitution was adopted in order to satisfy a violent public agitation for more liberal suffrage.

Rhode Island was for a long time involved in boundary disputes with Massachusetts and Connecticut, and was viewed with such suspicion by her neighbors on account of her liberal tendencies that she was not allowed to enter the federation of the United Colonies of New England. These boundary disputes were finally settled in 1862.

This State was the last to ratify the Federal Constitution, in 1790, holding aloof as an advocate of States rights, with the country towns arrayed against the maritime cities, which favored ratification.

The early prosperity of the colony was largely due to the friendly policy inaugurated by Roger Williams with the Narragansett Indians, and Indian corn and tobacco soon became prominent agricultural products. Nevertheless a conflict for supremacy between the whites and the Indians became in time inevitable, and the colony was drawn into King Philip's war after enjoying a long period of peace. In the "Great Swamp fight" of 1675 the Indians were utterly crushed in their stronghold near Kingston. There still exists a small Indian reservation in the southern part of the State.

The colonial system of farming attained a considerable development in Rhode Island, especially on the lands near Narragansett Bay. After corn and tobacco, the main crop grown was grass, and dairying was practiced extensively. Rhode Island cheese enjoyed considerable repute in the markets of the West Indies, and even in Europe. Wool was also produced in quantities, and horses were raised for export. The labor at this time was performed by African slaves and Narragansett Indians, who appear to have been quite efficient. Slavery was gradually abolished in the State after 1784. While some of the colonial estates were several miles in extent, the average size of the farms at this time was about 300 acres.

The remarkable progress of manufactures in the State from 1850 to 1900 has resulted in some decline in general farming, the general acreage having decreased 18 per cent during that time, and the acreage of improved land about twice as much. There has also been a considerable decrease in the number of sheep and swine, but significant increases in dairy cows and horses. Much attention has been given in recent years to fruit, and between 1890 and 1900 the number of peach trees increased fourfold, the majority of these being in Providence County. The cultivation of cranberries, strawberries, and other small fruits has also increased.

The most important crop in 1900 was hay, with corn, potatoes, and oats in the order named. Sweet corn and vegetables are also grown for market, and the market-gardening industry promises still further development near the larger markets. The amount of poultry raised throughout the State is exceptionally large, and may be said to constitute a characteristic feature of the system of farming.

The population of the State in 1790 was 68,825, and in 1900, 428,556. In 1729 the provincial legislature divided the province into three counties: Newport, Providence, and Kings (later changed to Washington County); in 1747 Bristol County was incorporated from lands formerly belonging to Massachusetts; and in 1786 Kent County was erected from part of the territory of Washington County.

CLIMATE.

The following table shows the normal monthly and annual temperature and rainfall for three stations—Bristol, Kingston, and Providence—as compiled from records of the Weather Bureau. It will be noted that Kingston, which represents the south-central part of the State, shows a slightly lower temperature and considerably greater rainfall. Many local variations occur, consequent on elevation and proximity to tidewater.

Normal monthly and annual temperature and precipitation.

Month.	Bristol.		Kingston.		Providence.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	° *F.*	*Inches.*	° *F.*	*Inches.*	° *F.*	*Inches.*
January	29.0	4.41	27.7	5.10	28.1	4.11
February	29.7	3.94	27.9	5.30	29.1	3.84
March	35.8	4.43	34.3	5.51	35.1	4.11
April	45.1	3.29	44.8	4.23	47.0	3.64
May	55.6	3.82	55.0	4.57	58.2	3.75
June	64.8	2.40	64.5	2.63	68.3	3.20
July	69.8	3.13	69.2	3.76	73.0	3.23
August	69.3	3.68	68.6	4.10	70.8	4.16
September	63.7	3.55	62.4	3.86	63.8	3.24
October	52.3	4.16	50.8	5.51	52.2	3.74
November	43.8	3.97	41.1	5.08	42.6	4.19
December	33.6	3.31	31.7	3.73	33.2	3.83
Year	49.3	44.09	48.2	53.38	50.1	45.04

PHYSIOGRAPHY AND GEOLOGY.

The topography of Rhode Island is of a generally hilly character, which tends to become more mountainous throughout its western interior, the elevations ranging from tide level up to 805 feet on Durfee Hill, the highest point in the State. The waters of Narragansett Bay extend from Long Island Sound northward through the eastern margin of the area in the form of a rough triangle having its apex at Providence, thus forming an important commercial waterway and constituting, with the islands of the bay, a feature of scenic interest. The region is well watered by numerous small streams, but there are no rivers of any considerable size, the main streams being the Blackstone and Pawtuxet rivers, which drain southeast into the headwaters of Narragansett Bay, and the Pawcatuck River, which drains southwest and empties into Long Island Sound at the southwest corner of the State. These rivers possess no properly defined valley systems, but, as they have considerable fall, with banks abutting throughout most of their course, they are extensively utilized for water-power sites.

Many salt ponds are to be found along the shoreline, while in the interior are scattered small fresh-water lakes characteristic of a glaciated region. There is a limited area of salt-water swamp, while the "Great Swamp," near Kingston, may be cited as an instance of the type of fresh-water swamp which occurs to a noticeable extent in the interior. Sand beaches along the coast have been formed, but only to a small extent.

The State may be divided into two distinct physiographic provinces—the eastern or Narragansett basin area, and the western and more mountainous area of hill remnants from one of the ancient east Appalachian mountain ranges. The Narragansett basin area comprises a field of low hills and glacial plains, which follows, at a distance nowhere greater than 3 miles, the western shoreline of the bay, and including the islands lying therein. It then extends northward from the head of the bay across the northern boundary of the State, and, including the islands and the waters of the bay, comprises about the eastern one-third of the State. The topography consists of smoothly rounded hills of easy slope, not exceeding 250 feet in height, and of level or gently rolling glacial plains, which are especially prominent near the head of the bay.

This province comprises decidedly the best farm lands of the State. The low hills are made up largely of shales, sandstones, and schists, which have been overlain by glacial till, oftentimes of coarser material. The soils, however, show the influence of the underlying finer-grained rocks, and these hills, while frequently stony, give a fairly heavy silty soil, which is the best upland soil for hay and general farming. The level or gently rolling plains of this province are made up of gravel, sands, and loams, which are of glacial deposition and which have been but little affected by river action. Where these glacial plains have a sufficiently loamy texture they afford the main truck soils of the State. Occasional areas of coarse gravel and rounded bowlders in these plains would indicate the action of strong glacial or subglacial currents and the transportation of the materials for some distance from the interior granitic ridges. The more loamy portions of the plains, free from bowlders, point to easier glacial currents and to the fact that the neighboring hills of shale and sandstone have contributed much of their material.

The bed rocks of this Narragansett basin area consist mostly of stratified conglomerates, sandstones, shales, and coals of Carboniferous deposition. The geological evidence indicates that this basin was an ancient erosion trough formed before the Carboniferous age, in which the Carboniferous deposits accumulated during a period of subsidence and were compressed and tilted by later mountain-building forces. A detailed account of the geology of this area may be found in volume 33 of the monographs of the United States Geological Survey, "The Geology of the Narragansett Basin," by Shaler, Woodworth and Foerste.

The characteristic upland soil type of the basin area is the Miami stony loam, while the Miami silt loam may be called the distinctive plain soil. The Warwick sandy loam is particularly prominent near the head of the bay, and occurs in larger distribution than the Miami silt loam, but it is not confined to the basin area, and is also to be met in the more level portions of the western uplands.

An abrupt escarpment along the western edge of the Narragansett basin separates it from the second or western physiographic province, comprising the more hilly western uplands. While this distinct geological demarcation does not afford, on account of the uniform glaciation to which the entire State was subjected in later times, any absolute boundary in the distribution of the soil types, it will nevertheless be seen to have affected their distribution in a pronounced degree.

This inland or more mountainous area embraces about the western two-thirds of the State. The region consists of rough and stony hills which vary in height from 100 to 800 feet, but which, despite their moderate elevation, frequently present a decidedly mountainous appearance. This series of hills represents at the present time the remnants of an ancient prominent mountain range, which has been subject to long-continued erosion and to repeated glacial attacks. The slopes are generally steep, and in such localities the usual glacial covering is frequently missing, and the igneous bed rock outcrops prominently. Such bare outcrops seem to indicate a local process of glacial abrasion instead of deposition, and distinct bowlder trains are often to be traced from these localities. These slopes and bowlder trains give in consequence very poor agricultural soils. Another feature of these upland hills is the general absence of sharp ridges or summits. After ascending steep slopes it is a common experience to find, instead of a ridge, a level summit plain where the soil covering has been less subject to erosion and has consequently a more loamy texture. This flattening or leveling of the summits would appear to be an obvious result of the grinding and shaving work of glaciers, and it is by such destructive action that much of the material deposited at lower levels as moraines and eskers has doubtless been obtained. There are no considerable glacial plains in this section, and such as do exist are generally composed of coarser materials than are found in the plains near the bay. The river valleys here, as throughout the State, have no distinctive fluvial character, but appear to have been quite remodified by serving as channels for glacial streams. Instead of alluvial soils, there are to be found along these courses coarse deposits of sand and gravel laid up in abrupt walls or terraces, with but occasional stretches of finer texture. Many small lakes abound in this region, and are generally bordered by the coarser types of soil, such as the Alton stony loam and Norfolk coarse sand, which are characteristic of the more prominent channels of glacial activity. In this section are to be found some considerable areas of fresh-water swamp, which are more prominent in this higher-lying region than in the lower area around the basin. Their existence at such relatively high elevations would seem to point to glacial interference with the natural drainage, analogous to glacial work in the formation of lakes. These swamp areas sometimes border the small glacial lakes, and may be regarded in many cases as incompleted lakes whose depressions serve as catch-basins for the surrounding land drainage. It is noticeable that the largest areas of these swamps occur just behind or to the north of the well-defined terminal moraine near the southern boundary of the State, where the glacial action was strongly marked.

The rocks of this section consist of granite, gneiss, mica, and hornblende schists and sandstones, with some crystalline limestone. They are mostly of great geological age—Archæan, Algonkian, and Cambrian, down to the Carboniferous—and include a complicated variety of igneous intrusions of varying age.

The characteristic upland soil of these western hills is the Gloucester stony loam, which is by far the most widely distributed type in the State. There are also some few areas of Miami stony loam in localities where the extent of weathering or the character of the glacial overlay has produced soils of more loamy texture than the general coarse texture of the Gloucester stony loam. The soil of the terminal moraine along the southern coast also consists largely of Gloucester stony loam, where these same granitic materials have been confusedly heaped along the front of the melting glacier.

It will thus be seen that the entire State has been subject to glacial agencies, and that probably for repeated periods. The till or bowlder-clay covering is not so thick here as in more central regions of glacial activity, being less than 10 feet. These till materials also contain less than the usual amount of clay, for the reason that this was a marginal district of glacial action, and that therefore the materials composing the till consist here largely of esker and other washed sands and gravels that had already been worked by the ice and had lost their clay content. The trough of the Narragansett basin was a natural point of discharge for these heterogeneous materials. The value of the soils for tillage is therefore uniformly less than in those glacial areas where the ice action has only proceeded so far as to liberate and deposit a sheet of true bowlder clay and where the clay covering so deposited has not again been lost by the repeated wash of glacial currents. The uniformly clayless character of the glacial till has served in this manner to make the soils also rather uniform, except where differences in the underlying bed rock have affected the surface soil.

On account of its geographic isolation, Block Island is given a separate discussion. This island, some 15 square miles in extent, is made up entirely of morainic material, presenting in a typical manner the rough, rolling, irregular topography, and interspersed with numerous miniature fresh-water lakes. The soils on the island, however, are somewhat heavier than those found in the morainic section of the State, north of Long Island Sound, and instead of the Gloucester stony loam the types found are the Alton stony loam and the Miami stony loam. Although many granitic bowlders and other glacial erratics occur, it is possible that the coarser morainic materials have been in this case mixed with, or modified by, the Tertiary coastal-plain deposits of clay and sand which underlie the island at no great depth.

SOILS.

Eleven soil types were recognized in the soil survey of Rhode Island. The actual and relative extent of each type is shown in the following table:

Areas of different soils.

Soil.	Providence sheet.	Newport sheet.	Total.	Per cent.
	Acres.	*Acres.*	*Acres.*	
Gloucester stony loam	186,880	138,240	325,120	46.8
Miami stony loam	58,688	91,264	149,952	21.6
Warwick sandy loam	61,568	21,248	82,816	11.8
Alton stony loam	18,496	51,456	69,952	10.1
Swamp	8,128	18,880	27,008	3.9
Norfolk coarse sand	22,848	3,456	26,304	3.8
Miami silt loam	....	4,928	4,928	.7
Galveston sandy loam	512	3,712	4,224	.6
Galveston fine sand	....	2,048	2,048	.3
Meadow	1,280	640	1,920	.3
Dunesand	....	128	128	.0
Total	358,400	336,000	694,400	....

MIAMI STONY LOAM.

The soil of the Miami stony loam consists of a mellow brown loam having an average depth of 10 inches, but varying in depth from 8 to 14 inches. The surface is strewn with erratic glacial bowlders, and frequent outcrops of bed rock occur, with a varying amount of gravel and rock fragments through the type. The subsoil is a reddish or yellowish silty and fine sandy loam or loam extending to 3 feet or more in depth, or underlain by bed rock at a less depth than 3 feet. In the cultivated fields the bowlders and as much of the bed rock as possible have been removed and built into massive stone fences. The angular character of the stones in the fences on this type, and the prevalence of rounded stones in the fences on the Alton stony loam, form a noticeable distinction between these two soils. The materials forming the Miami stony loam have no marked structure, but present a mass of fine earth, through which gravel and bowlders are irregularly distributed. At the foot of slopes a deeper and less stony covering has accumulated, while many of the steep slopes are unsuited to tillage because of the thinness of soil covering and the prevalence of rocks. Such areas, wherever practicable, have been indicated on the map by the rock symbol.

The smooth, rolling hills in the Narragansett basin are uniformly covered with this type of soil, and it there reaches its best development of texture and depth. Bordering the basin on the west the underlying rocks are of fine-grained and metamorphosed varieties for a width of from 1 to several miles throughout the length of the State, and the deposits of glacial till over these have given rise to the Miami stony loam. The coarser-grained granites lying outside the basin have so altered the thin covering of glacial till as to produce the inferior Gloucester stony loam type.

The Miami stony loam occurs as smooth rolling hills and tablelands, ranging in elevation from tide level to 500 feet, and presenting diversified topographic features, but as a rule it is less rough and broken than the higher lying Gloucester stony loam, with smoother contours and greater depth of soil covering. The soil is a firm, compact loam, maintaining a sufficient moisture supply during the entire growing season, and with the exception of a few small depressions is adequately drained. Although elevated and rolling it does not appear to suffer to any extent from washing. No large streams originate in this type, but it is crossed by several. Little erosion, however, has taken place since the close of the Glacial epoch.

The Miami stony loam is derived from a deposit of glacial till or ground moraine over the fine-grained rocks of the area, the character of the rock influencing the texture in no small degree. Thus, in the Carboniferous area the subsoil is somewhat heavier than where quartzite and fine-grained granites form the bed rock. The mineral constituents have undergone considerable mechanical disintegration, but no great amount of chemical decomposition, yet they are in a condition readily subject to chemical disorganization and have been modified by the accumulation and admixture of organic matter from vegetation.

The Miami stony loam is a typical glacial soil, naturally classed as a "general farming" or grass and grain soil, and in this section such is its general use, grass and corn forming the chief crop interests. In the southeastern part of the State potatoes and onions form an important addition to the crops already mentioned. Oak, chestnut, hickory, and ash form the principal timber growth at present, and the largest standing trees are found on this type. Apples and pears do well upon it.

Grass is the principal crop, and the yields average about 1½ tons per acre, while 4 tons is not an uncommon yield for a well-tilled field. Corn is next in importance, and yields an average of about 45 bushels per acre in a fair season. Much higher yields can be produced with careful tillage. Potatoes do well, and are carefully cultivated, giving a high average yield—over 150 bushels per acre—some fields yielding as much as 300 bushels per acre. Onions are an important crop on this type, giving an average yield of 400 bushels per acre. This crop also receives careful attention.

The Miami stony loam is the strongest general soil of the State, and is approached in natural productiveness only by the Miami silt loam. Its stony character and the difficulties of cultivation are the only drawbacks to its more general culture and improvement.

The following table gives mechanical analyses of typical samples of the fine earth of soil and subsoil of the Miami stony loam:

Mechanical analyses of Miami stony loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11688	Portsmouth	Brown loam, 0 to 11 inches.	1.9	4.4	2.7	12.5	24.1	41.3	12.6
11690	Fox Hill	Brown loam, 0 to 10 inches.	1.2	3.4	2.8	14.0	19.0	46.1	13.6
11691	Subsoil of 11690	Yellow loam, 10 to 36 inches.	3.6	8.8	5.6	16.5	18.6	37.4	9.0
11689	Subsoil of 11688	Yellow loam, 11 to 36 inches.	4.3	8.3	5.5	15.8	17.7	34.6	13.8

GLOUCESTER STONY LOAM.

The soil of the Gloucester stony loam is a light-brown sandy loam, usually containing a varying amount of fine gravel up to 5 or 10 per cent, and having an average depth of about 10 inches, underlain by a more sandy and gravelly subsoil of gray color. The subsoil is uniformly a mass of rock fragments, or may be entirely lacking, the thin surface soil resting on bed rock. From 20 to 80 per cent of bowlders and projecting bed rock is present on the surface and through the type, these rocks being for the most part angular and of coarsely crystalline structure, though a few rounded glacial erratics occur. A better phase of this type is sometimes developed in level areas and at the foot of slopes where the soil has accumulated to a greater depth and is more silty and loamy in character. In some small areas where the glacial covering is deeper it becomes quite heavy and approaches the Miami stony loam in character; otherwise it is very uniform throughout its large extent. It is covered with a stunted growth of chestnut, oak, white birch, and undergrowth. Not over 5 per cent is cleared, and but little is under cultivation.

This is the most extensive and widely distributed type of the area, occurring principally in the western half of the State and extending into Connecticut and Massachusetts. Another large area is found in the southeastern part, below Fall River.

In elevation the type ranges from tide level on the southern boundary to nearly 800 feet above at the northwestern limits of the survey, and presents a rough, broken topography, almost mountainous in character, although evidently much subdued by the glacial action so noticeable in the truncated tops and lenticular forms of the hills and narrow, groovelike valleys. From its steep position and the loose, open character of the subsoil the type is thoroughly drained, and the pastures are likely to suffer from drought in dry seasons.

The Gloucester stony loam is derived mainly from the immediately underlying rock, and only to a slight extent from glacial deposit. Over a large part of the area these rocks are of coarsely crystalline structure, and have broken down by mechanical processes of weathering, with little chemical decomposition, furnishing the source of the fine gravel so characteristic of the type, as well as of the finer materials. The overriding of this area by the ice in Glacial time must have removed a large amount of material, but little of the débris was left behind, and the present soil is loose, porous, and unproductive. This type is in part residual and in part glacial in origin, but its materials have in no case been transported any great distance, and the soil bears a distinct relation to the underlying or adjacent rock from which it has been mechanically derived.

So little of the type is cleared and under cultivation that it is difficult to form an idea of its productive capacity. The cleared fields are used largely for pasture and furnish rather uncertain grazing, being easily affected by drought. A very small acreage is planted to corn and potatoes, of which only light yields are obtained. The heavier phase of the type at the foot of some slopes is well suited to general farming, being only slightly less productive than the Miami stony loam.

Fully nine-tenths of the Gloucester stony loam is too rough and rocky for profitable tillage and seems to be best suited to forestry, or, in some places, to orcharding. The firewood obtained from the scant growth of chestnut, oak, and white birch furnishes the sole source of profit from large tracts of this soil. Under an intelligent system of cutting and thinning these woodlots would afford a continued and increasing source of profit. A few small peach and apple orchards were observed, which gave indication that both these fruits might be successfully grown in favorable situations. Poultry raising can be profitably carried on within reasonable distances to market or shipping point, and sheep raising would be feasible on many pastures not so well suited to cattle. Berries should do well, but none were observed under cultivation. Blackberries and huckleberries grow wild in profusion.

The following table gives mechanical analyses of fine earth of typical samples of the Gloucester stony loam:

Mechanical analyses of Gloucester stony loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11684	Pascoag	Brown loam, 0 to 10 inches.	3.8	6.1	4.2	20.2	18.7	41.7	4.8
11679	Bliss Corners	Red loam, 0 to 9 inches	4.6	6.4	3.9	19.5	23.0	36.3	5.9
11677	3¼ miles SE. of Niantic.	Medium sandy loam, 0 to 10 inches.	7.1	15.5	8.0	25.8	16.4	19.8	6.9
11685	Subsoil of 11684	Sand and gravel, 10 to 36 inches.	7.9	10.2	5.5	22.0	17.6	34.6	1.7
11678	Subsoil of 11677	Coarse sandy loam, 10 to 36 inches.	11.5	19.3	10.7	26.7	15.8	13.8	2.0
11680	Subsoil of 11679	Sand and fine gravel, 9 to 36 inches.	4.8	8.6	5.1	21.7	22.2	35.2	2.1

MIAMI SILT LOAM.

The soil of the Miami silt loam, to an average depth of 10 inches, is a brown silty loam containing a relatively small quantity of fine and very fine sand, which render it mellow and friable. The surface compacts when wet, but does not bake on drying. The subsoil, to an average depth of 32 inches, is a uniform plastic yellow silt loam, becoming more sandy in the last few inches, and resting on a substratum of coarse sand and gravel below 32 inches. The whole type is free from stones and gravel except for a few glacial erratics and rounded bowlders scattered on the surface. Most of these have been picked off the fields and built into fences or crushed for road material.

This type is found principally in the Kingston plain, where it presents a level surface, and near Peacedale, where it occurs as gently undulating hillocks and as a level table-land. Its range in elevation is slight, and the type as a whole is best described as level and unbroken.

Underdrainage is generally good, from the coarse and porous nature of the materials underlying the subsoil at no great depth, but the surface is usually so level and the soil so compact that water stands on the surface after heavy rains, and remains late in the spring after the melting of the snow. Areas sufficiently inclined to permit drainage, of course, do not suffer from standing water. The texture and structure of the soil and subsoil are such that they are capable of maintaining a sufficient moisture supply for the entire growing season; yet they are not so impervious as to impede the capillary movement of soil moisture, as do the heavy clays. The type therefore falls within the lighter class of desirable grass and grain producing soils, and is also adapted to a wide range of heavy truck and canning crops.

The Miami silt loam is derived from reworked glacial material laid down as a sediment from quiet water under uniform conditions. These sediments form a superficial layer rarely more than 3 feet in depth over the coarser water-deposited materials of the plain. The predominance of silt in such a localized area in only one of the plains would point to the Miami stony loam, which occupies large surrounding areas, as the probable source of the materials. The pale color of the subsoil indicates the low state of oxidation of the iron salts, while the brown color and mellow texture of the soil indicate that it has been derived from the subsoil by direct weathering and the incorporation of organic remains.

It is rather strange that such an easily tilled and responsive soil should not be more completely under cultivation, but many acres of this desirable land are allowed to grow up in brush and rank weeds. The experimental fields of the State experiment station are located on this type, and the results of its admirable work are therefore more directly applicable to this soil than to any of the others represented in the State. The yields of hay from these fields have averaged in recent years fully 4 tons per acre, and occasional yields have amounted to 6¼ tons per acre, showing the possibilities of this soil for this crop. The latter yield consisted of timothy, clover, and redtop, but the average yield quoted refers to timothy associated with some redtop. The yield per acre of shelled corn ranges from 60 to 75 bushels on the experiment farm, and an occasional yield has gone above 90 bushels, while the yield of Indian corn stover ranges from a little less than 3 tons to nearly 3½ tons per acre. Of the other important crops, potatoes have yielded from 250 to 380 bushels per acre, while the onion crop this season (1904) amounted to 423 bushels per acre. Under intelligent cultivation a wide variety of vegetables can be grown with profit on this type. It is well suited to apples and other fruits, and with the Miami stony loam ranks as one of the best general-purpose soils of the State.

The following table gives mechanical analyses of typical samples of this soil;

Mechanical analyses of Miami silt loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11700	1 mile SE. of Kingston.	Brown silty loam, 0 to 10 inches.	2.1	6.7	4.2	9.5	12.5	53.8	11.2
11698	¼ mile E. of Slocum..	Brown silty loam, 0 to 11 inches.	.6	1.9	1.1	2.2	13.4	64.9	15.8
11699	Subsoil of 11698	Yellow silty loam, 11 to 36 inches.	.7	1.6	.5	1.2	8.3	82.9	4.7
11701	Subsoil of 11700	Yellow silty loam, 10 to 36 inches.	1.5	5.4	2.9	6.6	13.7	62.6	7.3

ALTON STONY LOAM.

The soil of the Alton stony loam, to an average depth of 8 inches, is a brown or gray loose sandy loam, containing widely varying amounts of gravel and rounded bowlders up to 1 foot in diameter. Small local areas are free from bowlders on the surface and in the soil. The subsoil, to a depth of more than 3 feet, is a gray or yellow, sometimes slightly loamy sand and gravel, containing as much as 70 per cent of rounded, roughly stratified bowlders and large gravel, forming a very thoroughly drained and unretentive stratum, which is often underlain at about 10 feet by cross-bedded medium and fine sands of gray or yellow color extending to the bed of the formation.

Large areas of this type occur along Wood River, Big River, the upper Pawtuxet River and its tributaries, the Chepachet River, along the Blackstone River, around Woonsocket, and bordering many of the upland ponds. But little is found east of Narragansett Bay.

The topography of the type exhibits terrace remnants along the walls of the larger stream valleys, presenting flat tops and abrupt slopes from which the soil covering has been eroded; also rounded hillocks and broken ridges characteristically marked by glacial kettle-holes. This latter class of surface features is more general in the areas surrounding upland ponds, and there also the soil covering is usually thinner and the slopes often devoid of vegetation. In elevation it ranges from tide level to nearly the highest points, being exceeded only by the Gloucester stony loam and the Miami stony loam of the upland soils, but the range of elevation in any one location is slight, particularly where it occurs as a terrace remnant. The physical texture and structure of the whole type naturally favor rapid percolation of meteoric waters, and the subsoil is incapable of maintaining a sufficient amount of soil moisture to meet the needs of most crops. The level terrace areas and depressions in the rough areas of the type receive the wash from the adjacent slopes and the drainage from higher lands, and are capable of producing a fair crop in ordinary seasons, but are quick to suffer from droughty conditions. Practically none is in need of artificial drainage. The large streams which traverse the type have eroded comparatively narrow channels, in which small areas of more recent alluvial soil occur. The hilly areas have been modified but little since their disposition by stream erosion.

The Alton stony loam has been derived from a residual weathering of coarse and roughly sorted sediments deposited by glacial lakes and streams immediately following the close of that epoch, and in part from morainic material. The rather sharp line of demarcation between soil and subsoil indicates a final subsidence of more silty material. The soil itself, if of sufficient depth and not so completely drained by the porous underlying strata, would form a naturally productive soil. The materials of this type, being largely siliceous, have undergone little change through weathering except on the surface, where the decay of vegetation has modified their texture in no small degree.

The natural growth on the Alton stony loam consists of wild grass,[a] pitch pine, cedars, white birch, and some scrub oak and chestnut, together with a dense undergrowth. It is not so generally covered with pitch pine and wild grass as the Norfolk coarse sand, but next to that type it seems best adapted to that growth. It is perhaps best suited to truck and some canning crops, and to corn on the heavier areas, but what little is under cultivation brings poor and uncertain returns. Peaches might prove successful.

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[a] The wild or beard grass mentioned as natural growth on this type and the Norfolk coarse sand is *Andropogon scoparius* Mx, and much resembles the broomsedge so common farther south. It is considered by Professor Wheeler as a particularly characteristic indication of acid soil in this vicinity. (R. I. Agr. Exp. Sta. Rep., 1895, p. 240.)

Pasturage occupies most of the cleared portions of the type, and is fairly good in the early part of the season, but soon fails from lack of moisture. Corn is grown to some extent and yields up to 30 or 40 bushels on the best fields, though few reach this yield. Potatoes do well and are said to be more than ordinarily free from disease, but few are grown. Where favorably situated in regard to markets the early garden vegetables might well be grown and the soil improved through more intensive methods.

The following table gives mechanical analyses of fine earth of typical samples of the Alton stony loam:

Mechanical analyses of Alton stony loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11669	Locustville	Sandy and gravelly loam, 0 to 8 inches.	6.9	18.5	11.8	33.2	8.8	16.5	4.8
11671	2 miles S. of East Greenwich.	Sandy loam and gravel, 0 to 9 inches.	5.5	13.1	9.9	25.5	14.2	23.9	7.6
11670	Subsoil of 11669	Sand and gravel, 8 to 36 inches.	12.6	22.8	13.1	31.9	7.0	9.0	3.0
11672	Subsoil of 11671	Sand and gravel, 9 to 36 inches.	13.7	17.9	7.7	22.6	13.6	20.1	4.4

WARWICK SANDY LOAM.

The soil of the Warwick sandy loam, to an average depth of 10 inches, is a mellow brown sandy loam, usually containing some fine gravel. The sand content is of all grades and evenly distributed through the soil mass. The soil is free from stones and large gravel, and is warm, early, and easily tilled. The subsoil, to depths greater than 3 feet, consists usually of a few inches of loose sandy loam of yellow color, quickly grading into coarse, loose sand and fine gravel similar to the materials of the Norfolk coarse sand. Occasional areas occur having a subsoil identical with that of the Alton stony loam, and the type was undoubtedly formed from a thin layer of finer sediments deposited over these earlier coarse materials, which, when exposed, give rise to the last mentioned types. Usually where the subsoil consists of the coarse materials similar to the Alton stony loam subsoil the soil covering is thinner, ranging from 6 to 8 inches in depth, and more or less mingled with large, rounded gravel and occasional stones. This gravelly phase has been separated on the map from the more typical gravel-free areas, although little difference was observed in its crop-yielding capacity. This phase represents a transition between the conditions which gave rise to the Alton stony loam and those which formed the typical Warwick sandy loam. It occurs mainly as terrace remnants in narrow bands along the principal stream valleys, and having a higher general elevation, and because of its gravel content, ranging from 5 to 20 per cent of the soil mass, it is more thoroughly drained than the bulk of the main type, and is a slightly warmer and earlier soil, less well adapted to grass, but more favorable to the production of fruit and earlier truck crops. In other respects the general description of Warwick sandy loam applies with equal force to this phase.

Large, uniform areas of the Warwick sandy loam occur in the glacial plains of the Narragansett basin around the head of the bay, while smaller areas are widely distributed in the valleys and plains throughout the State. The surface features are level and unbroken, except by gentle undulations, and the elevation is usually low, part of the type occurring as stream bottoms, especially along the rivers and larger streams.

From the mellow character of the soil and the loose and porous nature of the subsoil, drainage is thorough and adequate, notwithstanding the level surface presented by the greater part of this type. It rarely suffers from drought, however, because of its low elevation and the proximity of the water table. Underdrainage is seldom required to remove surplus water, and grass and grain crops yield better than on soils of similar texture at higher elevation. Its position, therefore, as well as its texture and structure, places it among the lightest of desirable grass and grain soils.

The Warwick sandy loam is derived from a thin layer of recent sediments deposited over the coarser alluvial materials which were laid down in outwash plains and stream terraces at the close of the Glacial epoch. It has been much modified at the surface by weathering and cultivation, the rich brown color of the soil being due to the incorporation of organic matter. The subsoil gives little evidence of change since its deposition. The line of demarcation between soil and subsoil in this type is very sharp.

Crop interests are divided between grass, grain, and other general farming crops and the trucking and market-gardening interests which center around Providence. In yields of the former class it is only slightly below the two Miami types of the area, averaging nearly 1½ tons of hay per acre, with occasional yields of over 3 tons. About 40 bushels of corn per acre is the average yield of that grain. It excels the other soils of the locality in the production of heavy truck or market-garden crops, of which a great variety is grown. It is especially suited to those not required for the earliest marketing. Small fruits are well suited to it, and the more gravelly phases produce large yields of potatoes. Its level surface, freedom from large stones, ease of tillage, and ready response to the addition of fertilizing agents make it a highly esteemed, desirable soil, and much of it has been brought to a good state of cultivation, but little remaining uncleared. Heavy applications of lime are required to realize the best yields, and more attention should be given to crop rotation.

The following table gives mechanical analyses of fine earth of typical samples of this soil:

Mechanical analyses of Warwick sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11712	1 mile E. of Pawtucket.	Sandy loam, 0 to 10 inches.	7.7	15.9	12.1	18.8	11.9	23.3	10.0
11710	Hillsgrove	Brown sandy loam, 0 to 11 inches.	8.3	13.4	10.2	19.0	13.5	22.4	12.9
11711	Subsoil of 11710	Sand and gravel, 11 to 36 inches.	15.5	18.7	14.6	18.8	11.1	15.2	6.0
11713	Subsoil of 11712	Sand and gravel, 10 to 36 inches.	12.2	18.3	13.6	17.0	11.2	20.8	6.3

NORFOLK COARSE SAND.

The soil of the Norfolk coarse sand is a light-brown or yellowish sand of coarse to medium texture, containing more or less fine gravel, and varying in depth from 4 to 10 inches, with an average of about 6 inches. It is loose and porous in structure, is inclined to wash on slopes, and where bare of vegetation often shifts with the wind. The cultivated areas are more loamy on the immediate surface from the incorporation of vegetable matter. The subsoil to an indefinite depth is a uniform yellow or orange sand, of coarse, medium, and fine grades, and mixed with fine gravel much like the soil, but is usually more porous and unretentive, with a more uniform gravel content. It is occasionally underlain below 3 feet by the same materials as constitute the Alton stony loam subsoil or by cross-bedded medium and fine sands.

The principal areas of this type are found around the head of Narragansett Bay, in the vicinity of Providence; near Slatersville, in the northern part of the State; around Flat River Reservoir, and along Wood River, near Woodville. Much of the area in and around Providence has been altered by grading and filling and by intensive trucking and market-garden operations. The other areas are for the most part uncultivated.

The characteristic surface features of this type consist of level plains, long, narrow ridges, undulating hillocks, and steep valley walls, where these coarse sediments outcrop from underneath finer-textured overlying types. It occurs at different elevations from tide level to 500 feet, but most of it lies below 100 feet, and the range in each individual area is slight. From the coarse and porous nature of the materials this is naturally a thoroughly drained, dry, early soil, incapable of retaining more than a slight amount of moisture, and requiring no artificial drainage.

The Norfolk coarse sand is derived from the coarser sediments of the glacial outwash plains, and in general has been but slightly modified by subsequent weathering, being mainly siliceous and traceable in origin largely to the coarse-grained granites, the prevailing bed rock over the western half of the State.

The natural growth consists of scrubby pitch pines and wild or beard grass, which are very characteristic of the type in its untilled condition. This is a thin and naturally unproductive soil, and, though fairly well suited to some of the early truck crops in more southern latitudes, it is not so well adapted here because of climatic conditions. Peaches might do well where the water table is not too far below the surface, and melons are perhaps best adapted to this type of any of the market-garden crops. It is not suited to any of the cultivated grasses or small grains. Rhubarb, spinach, dandelions, celery, and other garden crops are grown on some of the low-lying areas near Providence, which do not part with their moisture so readily. Partial irrigation and heavy applications of coarse organic manures are used to secure good results even on the best of the type, with the result that the surface soil has been modified. Elsewhere little or none of the type is under cultivation, and no yields can be given in comparison with those of other soils of the State. Irrigation will be generally necessary to secure adequate returns, and in many cases is entirely feasible.

The following table gives the mechanical analyses of typical samples of this soil:

Mechanical analyses of Norfolk coarse sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11706	Pawtuxet	Sand and gravel, 0 to 8 inches.	9.0	12.0	15.7	39.0	14.7	7.4	1.7
11704	1 mile N. of Woodville.	Sand and gravel, 0 to 8 inches.	4.7	27.1	23.0	35.0	4.9	1.5	3.3
11705	Subsoil of 11704	Sand and gravel, 8 to 36 inches.	4.8	32.0	26.7	31.7	3.1	.3	1.4
11707	Subsoil of 11706	Sand and gravel, 8 to 36 inches.	6.7	12.3	14.0	44.1	15.2	5.9	1.5

GALVESTON FINE SAND.

Galveston fine sand is the name given to the familiar beach sands of the coast. The soil, to an average depth of 12 inches, consists of loose, incoherent sand of medium to fine texture, light gray in color, and containing varying amounts of shell fragments. The subsoil, to a depth of more than 3 feet, is of the same nature as the soil, but is often darker in color, containing more moisture and a greater percentage of shell fragments. The subsoil is often marked by thin bands of dark hornblendic material, roughly stratified.

This type occupies a narrow, nearly continuous strip along the seacoast from Watch Hill to Point Judith and forms small detached areas on the shores and island coasts in the lower part of Narragansett Bay.

Within reach of the waves and tides this type presents a smooth, hard surface, inclined toward the water and saturated with salt water. Beyond the reach of tides it rises in loose, irregular hillocks to a height of 30 feet. In the former position it is saturated, but in the latter it is almost completely drained and is capable of holding only an insignificant amount of moisture.

The Galveston fine sand consists of finely ground rock fragments of marine origin, and owes its formation to the action of waves and tides, modified by wind action at the higher elevations. These materials are of recent deposition and are still subject to frequent change. In character they are mainly siliceous, but are occasionally micaceous, depending on the character of rock from which they have been derived. This type is saturated with salt, and in its present condition is unsuited to agricultural purposes. It supports a scant growth of salt grasses and stunted shrubs, and in some cases it is desirable to extend the areas of this growth in order to bind the shifting surface and prevent the encroachment of these barren sands on more desirable adjacent soils.

The smooth beaches are of great value for recreation purposes, and command a higher price than much of the tillable land.

The following table gives mechanical analyses of typical samples of the soil and subsoil of the Galveston fine sand:

Mechanical analyses of Galveston fine sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11687	Quonochontaug Beach.	Gray fine sand, 0 to 36 inches.	0.0	1.5	13.0	84.3	1.0	0.0	0.1
11686	Narragansett Pier	.....do	.1	2.6	11.1	84.7	1.2	.0	.3

GALVESTON SANDY LOAM.

The surface soil of the Galveston sandy loam consists of a mass of salt-grass roots and turf mixed with sandy loam, having a depth of from 8 to 12 inches and varying in color from dark brown to black. It is underlain by a lighter colored subsoil of gravelly sandy loam.

This type represents the tide marshes of the area, and occurs adjacent to the Galveston fine sand and bordering the salt ponds inclosed by the barrier beaches. It is of small extent or importance and is confined to the southern part of the State.

The surface is level, and has a very limited range in elevation. Frequently the surface is much cut up by channels and waterways. Drainage is lacking, and can be accomplished only by diking to exclude the salt water. Although when reclaimed this type should furnish a more easily tilled soil than the Galveston clay occupying a similar position in other areas, it is doubtful if the expense would be warranted, owing to its limited occurrence in the area.

The Galveston sandy loam is the result of the mingling of the sands washed and blown over from the beaches, with the finer sediments deposited on the tidal flats, and of the subsequent growth and partial decay of the salt grasses which form the present surface. It affords a firmer surface than the Galveston clay of other areas, and the coarse hay it produces is therefore more accessible, although the yields are much lighter, being about 1 ton to the acre on the average. No other crops are grown, and the type is of little interest or value.

The following table shows mechanical analyses of typical samples of this soil:

Mechanical analyses of Galveston sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11401	2 miles N. of Narragansett Pier.	Dark-colored sandy loam, 0 to 12 inches.	2.8	12.2	7.7	16.6	16.4	32.9	11.3
11402	Subsoil of 11401	Gray sandy loam, 12 to 28 inches.	2.6	10.7	7.0	19.0	19.8	33.3	7.6

DUNESAND.

Three small areas of drifting sand occur in the State. They are of no agricultural importance and not of sufficient size to be a menace to adjacent lands. These dunes are composed of fine sand to a depth of more than 3 feet, and are so loose and unretentive of moisture that they support no vegetable growth.

MEADOW.

In this report Meadow is used to designate those low-lying, poorly drained lands along streams and in depressions. These areas are usually subject to overflow, and present a variable texture, which has less apparent influence on crop values than usual, owing to moisture conditions. The areas of Meadow are flat and narrow, partaking of the character of the surrounding types in which they occur. They are generally adapted to grass crops and pasturage, and are quite distinct from the areas of true Swamp. The slight extent of this type throughout the area renders further discussion unnecessary.

SWAMP.

Swamp has been used in this area to designate those lands totally or in greater part submerged and therefore unfit for tillage, to which no definite texture could be ascribed. A large part of the Swamp area is used to a greater or less extent as a source of water supply for mills, the surplus of rainy seasons being stored there for use in periods of drought. Until this practice is abandoned it will not be possible to reclaim any large portion of these soils to agricultural uses. Part of the Swamp area consists of bogs which do not serve as reservoirs, and are therefore capable of improvement. In many instances these could be readily drained by means of inexpensive ditches. Around the margins there is usually a belt where organic matter has not accumulated to any great depth; and this belt, after drainage, would form tillable fields of good quality, well adapted to market gardening and a variety of special crops. Where the peaty matter has accumulated to a considerable depth it would be difficult to bring it into condition for ordinary tillage, and such areas would be best suited to cranberries, which are at present cultivated only to a limited extent in this State.

AGRICULTURAL METHODS.

The agricultural methods employed in this section do not differ materially from the commonly accepted practices in similar latitudes, but are adapted to suit that line of general farming where corn is the main cereal and hay the chief farm product.

Plowing is carried to a good depth and is done mostly in the spring season, although fall plowing is practiced to some extent, and should become more general in connection with some cover crop as a soil improver.

There seems to be no well-arranged or well-adhered to system of crop rotation, but in a general way it may be said that grass land, after plowing, is planted first to corn, then to potatoes, or to potatoes first and then to corn, with an occasional crop of oats or rye; and then it is seeded to grass and allowed to remain in grass for an indefinite number of years. In those cases where intensive market gardening is carried on, with applications of large amounts of manure and other fertilizing agents, the rotation is of course much shorter and may embrace in one year a succession of several garden crops. These truck farms, being near the cities, are readily and cheaply supplied with manure from the city stables, in some cases even using it by whole train loads; but the use of manure in general farming throughout the State is not great, and is inadequate to maintain the land in its best yielding condition. A considerable waste of manure from negligent exposure to the weather was observed throughout the area.

The common use of menhaden fish scrap and seaweed on lands adjacent to the coast may be said to be characteristic of the section, and these fertilizers are highly esteemed for corn. The amount of seaweed that will accumulate on shore after a hard blow is often surprisingly large, and the shore rights for its use are carefully regulated.

Canadian unleached hardwood ashes are much used as a source of potash and lime, and through the persistent efforts of the State experiment station the use of lime as a corrective of soil acidity is being made a general practice. It has been shown that nearly all soils in the State are in an acid condition.

On account of the moderate size of the farms, and especially on account of the generally stony character of the soils, the use of improved horse implements is not so general as would be the case on larger and more level farms, and considerable hand-implement culture is necessary because of the interference of stones and bowlders. The husbandry must be constantly varied to suit local irregularities and individual locations and conditions. A characteristic method is the hauling of hay on the common farm wagon, with sharpened stakes set up along the edges of the box to hold the hay in place, instead of using the broad, flat racks so common in most hay-producing sections. The reason assigned for this practice is the rough, hilly character of so many of the farms. The greater part of the hay crop is stored in stacks without shelter, large barns for storage being much less common than in most Northern States. Silos are in general use on the larger dairy farms. Most of the orchards display great lack of care.

AGRICULTURAL CONDITIONS.

Generally speaking, the farming class of Rhode Island's population is divided by natural causes into two groups. A large proportion of those tilling the mellow soils of the Narragansett basin, favored both by the texture of the soils and easy access to markets, are prosperous to a high degree, comfortable buildings and well-kept fields and fences being the rule, while those less fortunately situated on the rough and stony hill lands in the western part of the State, with few exceptions give evidence of their struggle against the unfavorable conditions of rough, thin soils and difficulties of transportation, and here poorly kept fields and buildings and many abandoned farms are seen. About two-fifths of the total area of the State, or 268,248 acres, consists of unimproved and abandoned farms, many of which should be reforested, others used for orcharding, and a few, which are favorably located, for small fruits and berries.

Fully three-fourths of the farms are operated by the owners and their families, the remaining one-fourth being let to tenants for one or more years, sometimes for a money consideration, but more generally for a share of the crops produced—usually one-half.

Farms range in size from a few acres on the highly improved lands near the markets to several thousand acres in the rough and broken portions of the State, making the general average about 80 acres. The small farms are intensively cultivated to market-garden crops, while the very large ones are mainly in woodlots, and furnish a poor quality of grazing for stock. Over 80 per cent of the farms are free from incumbrance.

Farm labor is scarce and commands high wages throughout the area. The many mills and manufacturing enterprises furnish employment to thousands of the laboring class, and few are willing to leave the excitement and assumed advantages of town life for the quiet of the country, even at a high wage. Farm labor consists almost entirely of native whites of good intelligence, except on a few large truck farms near the cities, where many Italians, Poles, and other foreigners of recent arrival are employed. Many small farms are owned and successfully operated by this latter class throughout the State.

Agriculturally Rhode Island is a hay-producing State, the acreage of tame and cultivated grasses exceeding the total acreage of all other cultivated crops of the area combined. Timothy, redtop, and clover are the principal varieties grown, and the average yield of the first two throughout the State is about 1 ton per acre, while clover yields a general average of 1½ tons.

Corn comes next in importance to hay as an agricultural product, with a total acreage of over 8,000 and an average yield of 35 bushels per acre for the area, indicating a high yield on the heavier soils best suited to its production.

Potatoes rank next to corn in importance, occupying an area of nearly 6,000 acres, with the unusually high average yield of 145 bushels per acre. This crop is largely grown on the Miami stony loam on the island of Rhode Island. Early varieties are in favor and command a fair price in the local market, making this an especially remunerative crop. The importance of the truck and market-garden crops in this area may be readily foreseen, the acreage of miscellaneous vegetables amounting annually to about 5,000 acres, and the total value of the product reaching nearly half a million dollars.

Oats have steadily decreased in importance during the last half century, until the present area of this crop is only about 1,500 acres and the production less than one-fourth that of fifty years ago. The State does not produce enough of this grain for home consumption, although the climate is favorable and some of the soils are well adapted, the average yield per acre being as high as 30 bushels.

Apples do well, and there is a great opportunity for an extension of this industry on large tracts of land which are but poorly suited to general farming. Few orchards of commercial size were noted, but each farm has a small orchard, and most of the trees are sadly in need of pruning and cultivation. The orchard products represent a yearly value of about $150,000, which could be largely and profitably increased.

Of the small fruits, such as strawberries, raspberries, and currants, the product is marked by high quality, but the industry is confined chiefly to the immediate vicinity of the local markets, the value of this class of fruits being only about $50,000 a year.

Onions are an important special crop, the production of which is confined principally to the eastern part of the State. About 300 acres are grown annually, with the remarkably high average yield of 400 bushels per acre. Large areas of swampy and poorly drained land exist in the State, which, with a little preparation, would be well suited to onion culture, as they are usually rich in organic matter and unsuited to general crops, but capable of producing heavy yields of onions. This statement applies equally well to cranberries, which are little grown at present, with light yields, averaging a little more than 20 bushels per acre.

Rye, barley, and buckwheat are relatively unimportant and the acreage decreases from year to year. Considerable grain is cut green for stock feed and sown for forage and ensilage in the dairying sections. Millet and Hungarian grass are grown to some extent. Wild and salt grasses are cut and used for hay and bedding.

An area of over 175 acres in the State is devoted to flowers, shrubs, and fancy plants, which have an annual value more than twice as great as that of the orchard products.

A large part of the population of the area is engaged in manufacturing and mercantile pursuits, while the various fisheries produce the greater part of the income in the coast townships. Rough and dressed building stone is an important item in the resources of the State.

Considering the importance of the grass crop, it is natural that cattle and horses should occupy a leading place among the live-stock interests. Herds of cattle are mostly small or medium sized, and are kept for dairy purposes, supplying milk for the near-by markets. Most of the dairy farms are located along the rail and trolley roads and near the cities. Sheep raising, which was formerly an extensive industry, has rapidly declined of late, although large areas of rough land unsuited for other purposes would furnish good sheep grazing, and it would seem that this industry might be profitably extended in such localities.

Poultry raising is an extensive and steadily increasing industry in the State, and includes ducks, geese, and turkeys. This is a branch of agriculture that can be successfully carried on in rough areas difficult of tillage. It has its center in the southeastern part of the State, although of wide distribution over the entire area. The raising of swine is a scattered and unimportant industry compared with the attention given to other varieties of live stock.

With a few exceptions, the adaptation of the different soils to particular crops has been but slightly recognized or practiced, general farming being practiced almost universally, regardless of the fitness of soil conditions, grass and grain following each other in regular rotation on the cultivated fields, while the rough and undrained fields furnish pasturage and the family supply of fuel.

Near the markets, where local demand has created the necessity for supply, and competition has been more keen, the requirements of each crop have been more fully met, and we find the melons and early truck on the lightest sands, the cabbage, potatoes, etc., on the heavier sandy loams, and the onions and celery on richly organic soils.

Rhode Island is well supplied with transportation facilities, having over 400 miles of railroad, operated chiefly by the consolidated system, while numerous trolley lines radiate from the principal towns through all the more thickly populated districts in every direction, and give frequent service. Narragansett Bay furnishes good water transportation and has many good harbors, thus adding in no small degree to the wealth of the State. Rail communication to New York and Boston is direct and frequent, while the water route furnishes cheap shipping for bulky commodities to these and other ports. Passenger and freight lines make regular sailings from the port of Providence to New York, Baltimore, Norfolk, and Savannah.

Many miles of wagon roads have been macadamized, and the dirt roads are very good, except in the sandy areas and part of the rough and broken sections of the State. An abundance of good road material is at hand, and the mileage of paved road is increasing every year, to the great advantage of the agricultural population, as well as the pleasure seeker.

Providence, with its large population of mechanics and artisans, furnishes a good market for the bulk of the agricultural products of the State. It is centrally located and easy of access. Fall River, Mass., just over the State line, affords a good market for the southeastern portion of the State, while Newport, Narragansett Pier, and the numerous smaller summer resorts give a good demand for truck, fruit, poultry, and dairy products during the season. Woonsocket furnishes a local market for the northern section, and Westerly and Stonington for the southwestern section. Some of the bulky products find their way to New York and Boston, as does a small portion of the truck and poultry. It has been stated that four-fifths of the population of the State reside within 10 miles of Providence, and the greater part of the produce naturally goes to that market.

SOIL SURVEY OF THE VERGENNES AREA, VERMONT-NEW YORK.

By HENRY J. WILDER and H. L. BELDEN.

LOCATION AND BOUNDARIES OF THE AREA.

The Vergennes area, which comprises a part of the Champlain Valley, coincides with the Port Henry and Ticonderoga sheets of the United States Geological Survey. This area of 387 square miles, which includes a narrow strip along each side of Lake Champlain for a distance of 34½ miles, is comprised mainly in the townships of Ferrisburg, Panton, Addison, Bridport, Shoreham, and Orwell, in the State of Vermont, and Westport, Moriah, Crown Point, Ticonderoga, and Putnam, in the State of New York.

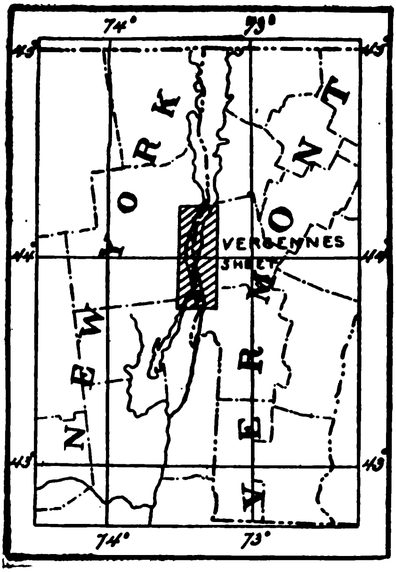

Fig. 1.—Sketch map showing location of the Vergennes area, Vermont-New York.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The first European settlement in this area was made in 1730 by the French, at Chimney Point, on the east shore of Lake Champlain. The next year a fort was erected at Crown Point, on the west shore, and in 1732 Colonel Lydias, an Englishman, purchased from the Mohawk Indians a large tract of land on Otter Creek, which included nearly the whole of the territory embraced in the present survey on the Vermont side of the lake. Another fort was built by the French at Ticonderoga in 1756. Many settlers followed in the train of the army, as both the French and English regarded the control of the lake as of great importance.

After the departure of the French, in 1763, New York and New Hampshire both laid claim to the territory which lay between them, then known only as "the wilderness," and later as the "New Hampshire grants," and the ensuing controversy over the right to grant and sell land therein caused the local inhabitants to band themselves together under the name of "Green Mountain Boys," to enable them to hold the lands upon which they had settled. The contention for the possession of these lands was lost sight of during the Revolutionary war, but did not cease altogether until 1791, when Vermont was admitted to the Union as a State. Essex County, N. Y., which embraces the area west of Lake Champlain, was organized in 1799.

In the war of 1812 there was much activity within the limits of this area. Macdonough held his Champlain fleet in winter quarters in Otter Creek and built new vessels just below the falls at Vergennes. With this equipment the naval battle of Lake Champlain was fought the following spring.

It is interesting to note, in connection with the early agriculture of the area, that during the decade ended with 1820 the Champlain Valley was celebrated for its production of wheat, which was made the chief crop. Troy was the principal market, and the grain was hauled there on sleds during the winter. The ruling prices were high, and in 1817 wheat brought $2.25 a bushel. Under these conditions farmers became highly prosperous, but the appearance during the next decade of the Hessian fly, the blight, and the wheat midge made the cultivation of that crop unprofitable, and its production was transferred to western New York, thus inaugurating the transitory movement westward which has marked constantly the cultivation of this grain in the United States.

The failure of the wheat crop, the knowledge that its successive production led to rapid depletion of the productivity of the soil, and the consequent awakening to the importance of manuring the old fields necessitated a resort to some other branch of farming. It was believed then that the tenacious character of much of the soil along the lake forbade the extensive cultivation of hoed crops, and this was undoubtedly the case at that time; but, happily, a profitable industry was introduced which not only made this unnecessary for the time being, but also brought a great deal of prominence to the agricultural interests of this section.

During 1809 and 1810 William Jarvis, American consul at Lisbon, had obtained about 4,000 Merino sheep from the confiscated flocks of Spanish nobles and had brought them to his estate at Weathersfield, Vt. From this importation and from a small flock of the Infantado family, imported about the same time by Colonel Humphreys, our minister to Spain, the most valued merinos are descended.[a]

Sheep husbandry became the leading industry of the valley, and in 1840 Addison County, Vt., had, in proportion to both territory and population, a greater number of sheep and produced more wool than any other county in the United States. French merinos were imported later, and it is claimed that both these and the Spanish breeds were so improved in this country that they far excelled the original importations.

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[a] Robinson's History of Vermont.

From these flocks many sheep were sent to the West, and as the business obtained a foothold there the wool-growing industry, which had been so profitable here, was unable to withstand the competition of the Western States, and sheep farming was gradually superseded by dairying.

Another product which gave much prestige to the early agriculture of this section was the Morgan horse. This famous breed originated in the town of Randolph, a few miles east of the area surveyed, and for a time exerted a most important influence, both on the character of the horses produced and the consequent remunerative prices for which they were sold. This very success, however, led to the disposal of the best stock for breeding purposes elsewhere, and the natural result was the steady downfall of the business here, until to-day little trace of this blood can be found.

With the rise of the dairy industry home-made cheese became the leading farm product. The cheeses were packed four or five together in casks made especially for the purpose by the local cooper. Butter was also made, and sold by barter at the village store, where, with little assorting, it was packed in large firkins and sent to the cities. These products of the dairy, together with pork, apples (both dried and in cider sauce), potash, and lumber, constituted the chief sources of income.

CLIMATE.

The following table, compiled from the records of the Weather Bureau, shows the normal monthly and annual temperature and precipitation of the Champlain Valley. The station at Cornwall is situated in the hilly region which borders the area on the east. The station at Burlington, a few miles north of the area, is but a short distance from Lake Champlain and is believed to represent well the conditions in the main part of the valley. The normals in the table are based on the records for the last nineteen years. The records at Burlington, which have been kept at the same point for a period of sixty-six consecutive years, show the normal temperature for that entire period to be 47.6° F., and the normal precipitation to be 32.96 inches, and are quoted to show the uniformity of the weather conditions for a long term of years. These data, and also the earliest and latest dates at which the temperature was 32° F. or below, are given by the courtesy of Mr. Charles E. Allen, who has taken these observations for the last twenty-six years.

Normal monthly and annual temperature and precipitation.

Month.	Burlington.		Cornwall.		Month.	Burlington.		Cornwall.	
	Temperature.	Precipitation.	Temperature.	Precipitation.		Temperature.	Precipitation.	Temperature.	Precipitation.
	°F.	*Inches.*	*°F.*	*Inches.*		*°F.*	*Inches.*	*°F.*	*Inches.*
January	19.5	1.99	19.3	2.68	August	69.0	4.36	67.9	3.73
February	20.6	1.57	19.2	2.16	September	61.5	3.63	60.9	2.92
March	28.7	2.04	29.1	2.30	October	49.5	2.58	49.7	2.26
April	44.6	1.84	45.8	1.56	November	38.2	3.19	36.1	3.26
May	58.2	3.18	57.0	3.14	December	25.4	1.85	25.4	2.26
June	67.8	3.17	67.1	3.33	Year	46.2	33.08	45.7	33.13
July	71.1	3.68	70.9	3.53					

Dates of first and last killing frosts.

Year.	Burlington.		Year.	Burlington.	
	Last in spring.	First in fall.		Last in spring.	First in fall.
1893	Apr. 26	Oct. 30	1899	Apr. 11	Oct. 22
1894	Apr. 10	Nov. 5	1900	Apr. 10	Oct. 20
1895	Apr. 11	Oct. 18	1901	Apr. 12	Oct. 23
1896	Apr. 9	Oct. 10	1902	Mar. 26	Oct. 17
1897	Apr. 20	Oct. 9	1903	Apr. 6	Oct. 25
1898	Apr. 21	Oct. 10			

PHYSIOGRAPHY AND GEOLOGY.

The portion of the Champlain Valley surveyed has the general appearance of a trough hemmed in by mountains. West of the center of the area lies Lake Champlain. This lake crosses the southern boundary of the area near its center, and extends a little west of north to Ticonderoga, where it receives the waters of Lake George, and thence to Chimney Point, opposite Port Henry. Turning northeast at the latter point the lake extends for a distance of 17 miles to the northeast corner of the area. South of Chimney Point the average width of the lake is about 1 mile, while north of that point it is about 2 miles. The shore line is irregular because of many bays, inlets, and "points." Some of these points are rocky, others are entirely covered by the Champlain clays, and still others disclose the rock formation only near the water level of the lake.

Extending back from the eastern shore line, the general surface features are those of a level or gently rolling plain, marked here and there by long, narrow ridges or hills and by drainage depressions. This plain gradually ascends with increasing distance from the lake, until near the eastern side of the area it gives way in many places to a series of hills and low mountains, the forerunners of the great Green Mountain system which lies but a few miles to the east.

Along the western side of the lake the foothills of the Adirondack Mountains extend in places to the water's edge, but more often there is a considerable intervening area which is level to moderately rolling near the lake, but hilly and rough as the mountains are approached. The same kind of topography is found in the district which lies west of Split Rock Mountain, north of Westport.

The entire drainage system, with the exception of that in the northwest corner of the area, which is cut off by Split Rock Mountain, flows into Lake Champlain. Some of the streams have cut moderately deep channels, and near their entrance to the lake the highways crossing them are steep. Few of the streams are swift, and the one second in size in the area is so sluggish as to receive the name "Dead Creek." The most important stream is Otter Creek, which, if fully developed, would furnish tremendous power at the Falls of Vergennes.

Geologists tell us that in an earlier age this region was worn down by ice, that the resulting land surface was left very uneven, and that glacial material, varying greatly in thickness, was then distributed over it. The entire region was then depressed, and the waters of Lake Champlain spread over all the lower-lying portions. During this submergence were deposited the post-Glacial or Champlain clays. These clays, which cover the main part of the area east of Lake Champlain and the low-lying portions on the west side, give rise to the most important soil type.

Above these clay deposits, along the lower mountain slopes on the New York side, are found terraces and deltas of post-Glacial sands and gravels.

Glacial material comes to the surface, or near to it, on the highest hills only, and in some cases this has washed down the slopes, mingled with the post-Glacial sands, gravels, or clays in variable amount, and has exerted some influence on the formation of small areas of surface soil.

As the ice was melting, sands were sorted and deposited in local banks and other small areas. Some of the small areas of sandy loam were probably derived in the same way. The soil on Snake Mountain is probably derived from Georgian sandstone. Decomposition of this rock has been slow and the resulting soil is thin, though this is due also in large measure to the rapid wearing away of the decomposition products on account of their steep position. Limestone is exposed for a short distance up the slope on the west side. The Champlain clays extend to the base, and are mixed there for a short distance with the soils washed down the mountain slope.

The hills south of Snake Mountain are usually of limestone formation. Several ridges and small hills of this or of slaty material occur in the valley. The post-Glacial clays always extend to the base of these elevations, and usually well up on the slopes, while the low ones are often entirely covered with them. The soil on the slopes of the high hills has been reenforced to a greater or less extent by material washed down from the older formations higher up on the slope.

SOILS.

There were mapped in this area nine distinct soil types, exclusive of Rock outcrop, Meadow, and Swamp. The area and proportionate extent of each type are shown by the table given below:

Areas of different soils.

Soil.	Acres.	Per cent.
Vergennes clay	129,984	52.4
Rock outcrop	43,008	17.4
Alton stony loam	29,056	11.7
Vergennes stony loam	17,024	6.9
Vergennes fine sand	8,384	3.3
Vergennes loam	4,352	1.8
Meadow	3,968	1.6
Vergennes gravelly loam	3,968	1.6
Vergennes black clay	3,584	1.4
Vergennes sandy loam	2,112	.9
Swamp	2,048	.8
Muck	384	.2
Total	247,872	

VERGENNES CLAY.

The surface soil of the Vergennes clay consists of heavy gray clay or light-brown clay loam, varying in depth from 6 to 12 inches. The subsoil is a gray, drab, or, rarely, light-brown heavy clay, somewhat tenacious when wet, but extremely stiff, compact, and intractable when dry. Wherever the clay loam is absent or so shallow that the processes of tillage go below it the upturned furrows of the underlying gray clay become white upon exposure to the atmosphere, and this has given rise to the local term "white-faced clay." Near Lake Champlain the principal part of the type is of this kind. With increasing distance from the lake, however, the clay loam areas are more numerous and of greater extent, but their close and indeterminate association with the "white-faced" clay renders their classification as distinct soil types unfeasible.

Minor variations of the Vergennes clay also occur. Small areas contain from 5 to 20 per cent of gravel and small stones, where otherwise the soil is typical. Local areas of sandy loam or sand, containing gravel and sometimes stones, are also found. These patches seldom exceed 5 acres, and are underlain by the typical clay subsoil at depths ranging from 12 to 36 inches.

The underlying limestone, which is usually buried deeply by later deposits, sometimes protrudes through the surface as narrow ridges or ledges. Where possible these have been included in the Vergennes stony loam, but many of them are too small to be thus represented. Other ridges and hills of small extent represent the Utica slate formation. On the steep slopes of many of these ridges outcrops of slate are frequent, and thin fragments are often strewn over the tops and the steepest slopes. The soil on these ridges is normally a medium loam, underlain by heavy loam or light clay loam. The soil seldom is 3 feet deep, but grades into a mass of slate fragments at depths ranging from 12 to 30 inches. The Vergennes clay of later age often completely covers the lowest of these hills and extends well up the slopes of the highest ones, so that only the largest of them can be mapped as stony loam. The soil in surface depressions of the Vergennes clay sometimes closely resembles or is identical with the soil of the Vergennes black clay. This is due to inadequate drainage conditions, which have made possible the accumulation of organic matter and fine material washed from the surrounding slopes. Similar soils are found along the boundaries of these two types. When the depth of such material is less than 6 inches, it has been mapped as Vergennes clay.

The Vergennes clay is the most extensive, as well as the most important, soil type in the Champlain Valley. It occupies the main part of the area of the present survey in the State of Vermont, broken for the first few miles back from Lake Champlain only by occasional small areas of other types, until it approaches the foothills of the Green Mountains on the east. On the New York side it includes nearly all of the lower lying portions.

The type is for the most part level, or but very gently rolling, broken only here and there by occasional ridges of stony loam. Along the east side of the area, and also west of Lake Champlain, the topography is more hilly. On each side of the lake the streams have cut deep courses for some distance back. On the New York side narrow, flat bottoms often extend along these streams. Such strips are usually Vergennes sandy loam, but they seldom exceed 2 acres in extent and most of them are even smaller. Similar areas often occur on small, low-lying points which jut into the lake, though when the banks are high they are commonly the "white-faced" clay phase of the Vergennes clay.

The surface drainage of the Vergennes clay is adequate for the greater part of the formation, though there are many surface depressions which should be drained artificially. Most of the type, however, is extremely compact and so impervious to moisture that the seasons when the soil may be worked to advantage are seriously shortened. On this account much better crop returns could be secured if this soil were underdrained. The chief benefit from underdraining, however, would be derived, not as the direct result of the removal of the excess surface water, but rather from the lengthening of the seasons in which the land could be worked, the much more thorough methods of cultivation which could be followed if the supply of moisture were under better control, and the consequent decreased susceptibility to drought.

The Vergennes clay is derived chiefly from the post-Glacial or Champlain clays, which, with the exception of the mountains and highest hills, overspread the entire region. The glacial material comes to the surface, or nearest to it, on the hills, and in some cases this has been washed down the slopes and mingled with the post-Glacial clays, thus exerting some influence on small areas of the type.

Hay is the most important crop, and yields from 1 to 3 tons per acre. The system of farming is such that the average yield is very low when the possibilities are considered, being probably not much above 1 ton per acre. Some farmers maintain an average yield of 1½ tons per acre. Corn yields from 20 to 50 bushels per acre, with an average of 30 bushels; and oats 20 to 60 bushels, with an average of 25 bushels per acre.

The Vergennes clay is an excellent soil for the production of hay, and should bring an average yield of 2 tons per acre with a four-year rotation. It is not an ideal corn soil, but profitable yields of that grain may be secured, and it should give an average yield of 40 bushels of shelled corn per acre. Oats and barley both yield well and leave the ground in good condition for seeding. This type makes excellent pasture, and much of it is so used for the last year or more of a long rotation.

The Vergennes clay is adapted to the crops which are generally grown upon it, but there is much chance for improvement in methods of management and cultivation, which will be treated further under the chapter on Agricultural Methods.

The following table shows the results of mechanical analyses of both soil and subsoil of this type:

Mechanical analyses of Vergennes clay.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11067	½ mile N. of Orwell..	Gray heavy clay, 0 to 6 inches.	2.2	5.5	3.5	3.7	2.0	15.4	67.6
11069	1 mile W. of Vergennes.	Gray heavy clay, 0 to 7 inches.	.5	2.3	2.2	3.5	3.0	19.7	68.7
11071	2 miles S. of Westport.	Mottled brown clay, 0 to 6 inches.	2.0	2.4	1.2	1.4	2.6	21.1	68.9
11070	Subsoil of 11069	Brown heavy clay, 7 to 36 inches.	.3	1.6	1.5	2.4	2.5	24.4	67.2
11072	Subsoil of 11071	Brown heavy clay, 6 to 36 inches.	.0	.4	.5	1.3	2.4	25.4	69.9
11068	Subsoil of 11067	Gray heavy clay, 6 to 36 inches.	.2	2.4	1.7	2.1	2.1	15.6	75.8

VERGENNES BLACK CLAY.

The surface soil of the Vergennes black clay consists of from 6 to 15 inches of black loamy clay or heavy black clay loam. This soil is very tenacious and sticky when wet, but granular and friable when dry, and contains a high percentage of organic matter. The subsoil is heavy, tenacious drab clay. In local areas this is somewhat plastic, but more often it is underlain at 24 inches by stiff, heavy clay similar to the subsoil of the Vergennes clay.

The areas of this type are small, only one exceeding 2 square miles in extent. The most important occurrence is along Lemon Fair Brook, in the eastern part of Bridport Township. Smaller areas are associated with the Vergennes clay or occur as narrow strips along minor stream courses.

The surface of this type is either flat, as along the Lemon Fair, or basinlike, as in the smaller areas. In the former case the natural drainage afforded by the Lemon Fair is somewhat sluggish and the area was formerly very wet. A few ditches have been dug, and the portions most easily drained have thus been made very productive. Much more extensive systems of lateral ditches, however, would vastly increase the value of this soil, and if properly managed their construction would be a profitable investment.

The Vergennes black clay owes its origin to depressions left in the Champlain clays of post-Glacial time. Such depressions have received the drainage from the higher lands, and in this way the finer sediments washed from the surrounding slopes have been accumulated. This material, mingled with the decaying vegetation, has given rise to the rich black soil of this type.

The Vergennes black clay is naturally a very strong soil. Artificial drainage, however, is absolutely necessary for most of the type if its excellent possibilities are to be realized to any degree of completeness, and, in fact, there is none of it which would not be greatly improved thereby. If this were done the Vergennes black clay would be by far the best soil of the area for the production of corn, and would equal the best corn soils of the Middle West. At present but little of it is cultivated. Hay is cut from the best-drained portions for long terms of years, with altogether too little reseeding. Excellent yields are obtained for a few years after each reseeding, but as the yield diminishes the fields are used as pasture. The more poorly drained portions are used only for pasture.

The Vergennes black clay of the Champlain Valley is an admirable soil for the production of corn and hay, and it offers superior opportunities for profitable development.

The following table shows the results of mechanical analyses of both soil and subsoil of this type:

Mechanical analyses of Vergennes black clay.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 *to* 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11075	3 miles SE. of Bridport.	Black clay, 0 to 12 inches.	0.8	3.8	2.2	3.1	2.5	33.4	53.4
11077	4 miles SE. of Panton.	.....do....................	.9	2.1	1.5	3.7	2.8	33.5	55.5
11076	Subsoil of 11075......	Black clay, 12 to 36 inches.	2.6	3.1	1.8	2.8	2.2	29.7	57.8
11078	Subsoil of 11077......	Gray clay, 12 to 36 inches.	.0	1.0	1.0	4.2	3.8	31.3	58.6

VERGENNES STONY LOAM.

The surface soil of the Vergennes stony loam consists of clay loam, or, more rarely, loam, to an average depth of 8 inches. The subsoil of the clay loam phase is the gray clay of the Vergennes clay formation, but its depth is variable, depending on the position of the underlying rock.

This type occupies long, narrow ridges or low hills throughout the Vergennes clay formation, and also the lower slopes of the higher hills.

The ridges are corrugations of the most resistant parts of the limestone formation which underlies this region. A few of these may have been high enough to prevent the Champlain clays from completely covering them, but it is more likely that they were once covered by these deposits, which since have been eroded away from the steep positions, leaving the bare rock exposed. Small portions of the type are merely rock outcrop, but these are seldom of sufficient extent to be indicated on the map. Large quantities of limestone fragments are scattered over local areas.

Between the ledges, which are usually long and very narrow, the hollows are often comparatively free from stones on the surface, but are underlain at 3 feet or more by limestone ledges. In such cases a few inches of soil next to the limestone appears to be derived directly therefrom, but it can not be distiguished anywhere near the surface, though it is undoubtedly mixed to some extent with the Vergennes clay which overlies it. Aside from this minor influence this phase of the type has been derived directly from the Champlain clays.

Where the Vergennes stony loam occurs on the lower slopes of hills whose upper slopes were above the line of the post-Glacial deposits, the type is somewhat variable. On the western slope of Snake Mountain, for example, the soil is mainly clay loam or heavy loam, but patches of sandy loam are frequent. Such areas, if they were of sufficient extent, should be mapped as Alton stony loam. The amount of stones along this slope varies greatly, but in general increases gradually with the ascent of the mountain. The limestone near the base gives way farther up the slope to sandstone and quartzite.

A light phase of this type is found on the elevations locally known as "slaty hills." This soil ranges from a light to a medium loam, containing from 15 to 75 per cent of slate fragments. The subsoil is medium to heavy loam, or, rarely, clay loam. The slate fragments vary in size, the greater number being no larger than Indian arrowheads, but pieces a foot long from 2 to 4 inches wide and an inch thick are not uncommon. Where suitable for tillage this phase is highly esteemed for the production of potatoes, and good yields of excellent quality are obtained. Many of these hills, however, are used only for pasture or allowed to grow up in forest.

Small fields on the most level portion of the Vergennes stony loam are tilled and medium yields of corn and hay are secured, but low prices of soils better adapted to tilled crops militate against the extensive cultivation of this type, most of which is used as pasture or woodland. The best apple orchard seen in the entire area is on this type, and the fruit produced is of high quality. A large part of the Vergennes stony loam offers excellent opportunities for the production of apples on a commercial scale by the employment of modern methods of orchard cultivation, and should be used for this purpose.

The following table gives mechanical analyses of the fine earth of the soil and subsoil of this type:

Mechanical analyses of Vergennes stony loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11063	1 mile SW. of Richville.	Heavy loam, 0 to 9 inches.	1.0	3.0	3.3	11.1	16.6	41.2	23.8
11065	2 miles E. of Bridport.	Light clay loam, 0 to 9 inches.	2.0	8.7	13.2	22.1	8.1	20.8	25.2
11064	Subsoil of 11063	Clay loam, 9 to 36 inches	1.0	3.0	3.0	10.8	14.3	40.6	27.4
11066	Subsoil of 11065	Clay loam, 9 to 30 inches	2.1	7.0	10.8	22.6	9.3	18.3	29.7

VERGENNES FINE SAND.

The surface soil of the Vergennes fine sand consists of a dark-brown, black, or yellow loamy fine sand to a depth of from 6 to 10 inches. The subsoil is a yellow or light-brown medium sand, which rests upon the basal clays of the region at depths ranging usually from 3 to 4 feet, though in rare instances the sandy material may be 6 feet or more in depth. Small amounts of gravel are not infrequent in both soil and subsoil. There is a phase of the type west from Streetroad, 3 miles northwest of Ticonderoga, and in certain other small areas near the bases of hills where the surface soil is less loamy, is lighter colored, and over it are scattered small quantities of stones and bowlders; also along the foothills in New York less organic matter has been accumulated in the surface soil, and consequently the color is lighter than in the true type.

The Vergennes fine sand is found in scattered areas of rather small extent, and its surface features are much varied. In Vermont it varies only slightly, if at all, in elevation from the Vergennes clay, and in this position it represents a water deposit. West of Vergennes, between Dead and Otter creeks, occurs a level, poorly drained area, mostly covered with a scrubby growth of trees, the soil here and that of the smaller areas near Little Otter Creek being derived from late sedimentary deposits. In New York the type appears along the lower slopes which lead from the Vergennes clay adjoining Lake Champlain to the Alton stony loam of the Adirondack foothills, in which position the soil has probably been formed from the decomposition products of the mountains above, modified somewhat by shore deposits. Areas occur among the foothills of the Adirondacks where both their topography and derivation are varied. On certain slopes this soil seems entirely colluvial; again its origin is undoubtedly sedimentary; while in still other places it has been derived from one of these sources, modified by the other. Some of the areas are quite hilly, and suffer from lack of moisture in a season of normal rainfall. With the exception of a few low-lying areas, the type is usually well drained.

The Vergennes fine sand is well adapted to truck and garden crops and small fruits. It is more commonly used, however, for general farming, and fair yields of corn, oats, and hay are produced. It requires plowing and reseeding more frequently than the heavier types, and hence is seldom appreciated, inasmuch as hay is the chief crop. If a system of crop rotation were adopted, including a crop of corn and one of clover for two out of every four years, this soil should bring good returns. No crops are grown at present on certain portions of the type where the soil is of very light texture and too deficient in organic matter for the staple farm crops.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Vergennes fine sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
11049	½ mile N. of Crownpoint Center, N. Y.	Yellow medium sand, 0 to 6 inches.	1.1	4.6	9.0	43.0	27.3	9.2	5.5
11047	3 miles W. of Vergennes.	Medium to coarse sand, 0 to 8 inches.	2.7	13.2	19.4	29.6	17.7	11.5	5.7
11053	2 miles SE. of Crownpoint Center, N. Y.	Fine sandy loam, 0 to 8 inches.	.8	.6	.7	8.5	41.0	41.0	7.3
11055	2 miles W. of Vergennes.	Fine sandy loam, 0 to 10 inches.	.7	2.9	11.6	46.3	19.8	10.6	7.9
11051	2 miles W. of Ferrisburg.	Medium sandy loam, 0 to 9 inches.	4.1	13.8	15.4	24.3	19.3	12.4	10.5
11048	Subsoil of 11047	Yellow coarse sand, 8 to 36 inches.	5.0	13.4	22.8	41.8	10.1	3.4	3.5
11052	Subsoil of 11051	Yellow sand, 9 to 36 inches.	2.6	9.0	14.1	55.4	10.9	4.0	3.6
11054	Subsoil of 11053	Fine loamy sand, 8 to 36 inches.	.1	.3	.9	24.9	40.1	28.4	5.4
11050	Subsoil of 11049	Yellow medium sand, 6 to 36 inches.	.6	3.9	8.0	34.9	28.2	18.3	5.8
11056	Subsoil of 11055	Yellow fine loamy sand, 10 to 36 inches.	.4	.8	2.4	33.7	36.2	18.3	8.0

The following sample contained more than one-half per cent of calcium carbonate ($CaCO_3$): No. 11054, 0.8 per cent.

VERGENNES SANDY LOAM.

The surface soil of the Vergennes sandy loam consists of from 8 to 30 inches of black or dark-brown medium sandy loam. The surface material does not differ essentially in texture from the Vergennes fine sand, but the subsoil is drab clay loam or clay. Often there is an intermediary gradation zone between the typical soil and subsoil, consisting of sticky sandy loam or light clay loam. Such material ranges from 6 to 15 inches in thickness, and owes its origin to a reworking of the surface of the underlying clay with the later sandy deposits. In a few places the typical soil is underlain at an average depth of 12 inches by a layer of medium sand which rests directly upon the heavy underlying clay.

The Vergennes sandy loam occupies but a few scattered areas, of which the largest is near the mouth of Otter Creek. Its surface there is nearly level, but is marked sometimes by hummocks and low swells which extend for a considerable distance. The scattered areas are usually rolling or they occupy the lower parts of slopes.

The type is well drained, except in local areas near the mouths of the large creeks, where the water table is near the surface.

The Vergennes sandy loam is derived, in the low-lying areas, from late sedimentary deposits overlying the Champlain clays. The scattered areas are either colluvial material or shore deposits overlying the Champlain clays.

Much of this minor type is uncultivated and the tilled portions are so small that they are farmed usually with adjoining types, and as a consequence crop yields are not given.

The Vergennes sandy loam, where well drained, should produce good yields of corn, clover, and late truck.

The following table shows the results of mechanical analyses of both soil and subsoil of this type:

Mechanical analyses of Vergennes sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11081	4 miles W. of Ferrisburg.	Heavy fine sandy loam, 0 to 10 inches.	0.6	3.3	3.1	11.5	45.4	24.8	11.4
11079	3 miles W. of Vergennes.	Fine sandy loam, 0 to 12 inches.	.9	5.4	4.2	17.8	24.1	33.2	14.4
11082	Subsoil of 11081	Clayey sandy loam, 10 to 36 inches.	.0	.6	.4	13.8	36.5	28.5	20.0
11080	Subsoil of 11079	Gray clay loam, 12 to 36 inches.	.0	.7	.9	4.2	13.2	45.5	35.3

VERGENNES LOAM.

The surface soil of the Vergennes loam consists of heavy fine sandy loam or loam to a depth averaging 10 inches. The subsoil is either a plastic mixture of clay and sand, or medium to heavy loam, which often grades at 3 feet into the stiff subsoils of the Vergennes clay. The subsoil occasionally contains a low percentage of gravel and stones. North of Crown Point the soil is underlain in places at a depth of 10 inches by a band of medium sand, which at a depth of 20 inches grades into loam or clay loam.

The Vergennes loam occurs in only a few scattered areas. Near the mouth of Otter Creek and at the head of Bulwagga Bay it is level and drainage is somewhat sluggish in the spring when the lake is high, but the soil usually dries in time to plant corn. The Vergennes loam of these areas was derived from post-Glacial deposits, modified somewhat by stream action. The other occurrence of Vergennes loam is upon low, rounded or flat-topped hills and gentle slopes. In such areas the soil is well drained and is derived from post-Glacial deposits which, in some instances, have been modified somewhat by colluvial material.

The Vergennes loam produces an average yield of 40 bushels of corn, 35 bushels of oats, 35 bushels of barley, and 1½ tons of hay per acre. It is a more popular soil than the Vergennes clay, as it is much easier to work and consequently is more efficiently farmed. It is the best corn soil in the area, and, as desirable corn soils are not abundant here, it should be used largely for the production of that grain in a rotation with clover.

The following table shows the results of mechanical analyses of both soil and subsoil of this type:

Mechanical analyses of Vergennes loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11059	4½ miles S. of Addison.	Brown loam, 0 to 12 inches.	1.1	3.0	3.1	14.6	32.1	26.9	19.1
11057	5 miles SE. of Bridport.	Brown medium loam, 0 to 9 inches.	3.1	4.9	6.3	22.9	20.5	22.9	19.6
11060	Subsoil of 11059	Sandy clay, 12 to 36 inches.	2.3	4.2	3.8	14.1	31.3	22.9	21.3
11058	Subsoil of 11057	Heavy loam, 9 to 36 inches.	3.4	6.0	7.1	22.3	17.6	21.8	21.9

MUCK.

The surface soil of the Muck consists of from 6 to 24 inches of organic matter mixed with clay and sand. This is underlain by stiff, heavy clay. In places the Muck is less thoroughly decomposed, and small quantities of peat are found. There is but one area of Muck within the present survey large enough to map, and that is of small extent. It forms a fringe which nearly encircles the swampy area occupying a depression in the Vergennes clay just north of Shoreham village. Near the borders of the Vergennes clay it is fairly well decomposed, and yields fair crops of second quality hay and pasturage. Bordering swamp it is poorly drained, and at present the expense of artificial drainage would scarcely be warranted.

MEADOW.

Low-lying areas adjacent to stream courses, with a variable soil formed by stream deposits, yet too well drained for classification as Swamp, and chiefly utilized for pasturage, have been mapped as Meadow.

SWAMP.

An area of about 2 square miles lying just north of Shoreham village was mapped as Swamp. This area occupies a depression in the Vergennes clay, and its natural drainage is so inadequate that it has no present agricultural value. It is too wet even for pasturage, and its only use is to furnish firewood. A few other small areas too wet for classification as Meadow have been included in this type.

VERGENNES GRAVELLY LOAM.

The surface soil of the Vergennes gravelly loam consists of from 6 to 10 inches of sandy loam, containing from 10 to 45 per cent of fine gravel, pebbles, and small stones. The subsoil consists of light sandy loam or sticky sandy loam, with gravel content similar to that of the soil. The subsoil, in its lower depths, often grades into sand, with a high content of fine gravel.

There are only a few scattered areas of the Vergennes gravelly loam, and of these the largest and most important lies west of Port Henry.

The type occupies two physiographic positions: Low bars and ridges surrounded by the Champlain clays, where it represents delta deposits; and broken terrace formations along the ancient shore line.

This soil is always well drained, both on account of its texture and its position, and, with the exception of the low, narrow bars which rest upon clay at a depth of about 3 feet, it is very susceptible to drought.

Only the most loamy portions are tilled. Such fields produce an average yield of 25 bushels of corn and 1 ton of hay per acre for the first two years after seeding, but frequent reseeding is necessary. Potatoes do well, and the soil is best adapted to their production, alternating occasionally with clover, which yields well in wet seasons.

The following table shows the results of mechanical analyses of the fine earth of both soil and subsoil of this type:

Mechanical analyses of Vergennes gravelly loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11043	¼ mile N. of Crownpoint, N. Y.	Sandy loam, 0 to 6 inches.	7.7	17.8	14.8	19.1	13.8	17.9	9.4
11045	5 miles S. of Addison.	Sandy loam, 0 to 8 inches.	7.2	15.6	12.9	18.9	8.8	23.4	12.8
11044	Subsoil of 11043	Sand containing gravel, 6 to 36 inches.	4.6	17.6	26.9	26.5	7.0	10.4	7.0
11046	Subsoil of 11045	Light sandy loam, 8 to 36 inches.	6.0	12.9	15.9	25.9	7.6	19.5	11.6

The following sample contained more than one-half per cent of calcium carbonate ($CaCO_3$): No. 11043, 0.8 per cent.

ALTON STONY LOAM.

The surface soil of the Alton stony loam ranges from light to heavy sandy loam, with a depth of from 6 to 10 inches. The soil is brown or yellow in color, and contains from 20 to 60 per cent of gravel, stones, and bowlders. The typical subsoil is a medium sandy loam, with from 20 to 80 per cent of stones and bowlders, but it presents a wide range of variations. In some places there is enough fine material present for classification as clayey sandy loam, while again it is chiefly medium and fine sand. The stones, rock fragments, and bowlders are chiefly gneisses, gabbros, quartzites, and sandstones. In many places these are so abundant that cultivation is hardly worth while, but at former times they have been removed from many small fields and piled in heaps or laid in stone walls. South from Crown Point this type contains patches of an acre or more which are comparatively free from stones. The soil texture of such areas does not differ from that of the true type.

East of Lake Champlain the Alton stony loam is found chiefly in the townships of Orwell and Shoreham. West of the lake it occurs in many irregular areas throughout the length of the survey.

The topography of this soil is always hilly. Small fields which are practically level are found on flat-topped hills or benches, but most of the type is much broken by steep hills and ridges. In New York it often occupies the lower slopes of the hills and mountains whose upper slopes are rock outcrop.

The greater part of the Alton stony loam is very susceptible to drought, but where the subsoil is heaviest crops suffer but little from lack of moisture in normal seasons.

This soil is derived chiefly from colluvial material representing the weathering and decomposition of glacial deposits, modified in varying degree by post-Glacial sands and gravels.

Only a small portion of the Alton stony loam is cultivated, and the tilled fields are so small, irregular, and broken that crop yields are practically unobtainable. Certain portions bring good yields of potatoes and moderate yields of corn and grass. A considerable part of the type furnishes good pasturage early in the season, but most of it is left in woods. Apples do well on the heaviest portions, and where not too rough this phase is best adapted to their production. The sugar maple also thrives and represents probably the best use to which certain parts of the type can be put. Other portions should be used as permanent pasture, but most of it is best suited to forestry.

The following table shows the results of mechanical analyses of the fine earth portion of the soil and subsoil of this type:

Mechanical analyses of Alton stony loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11039	1¼ miles SE. of Orwell	Heavy sandy loam, 0 to 8 inches.	2.6	6.2	6.5	19.8	23.6	28.8	12.4
11037	1¼ miles NE. of Shoreham.	Medium sandy loam, 0 to 8 inches.	3.0	6.5	7.0	17.5	19.5	29.1	17.4
11040	Subsoil of 11039	Sandy loam, 8 to 36 inches.	3.2	6.2	7.7	23.0	25.0	26.5	8.1
11038	Subsoil of 11037	.....do	2.9	6.7	7.1	19.2	21.2	28.8	14.1

ROCK OUTCROP.

All land too rocky and steep to cultivate is designated on the map by the symbol ✓. The soil of such areas, where soil exists, is usually a thin, sandy loam overlying a mass of rock fragments or a ledge. The surface is strewn with bowlders and rocks, and small cliffs are common. Occasionally, however, small areas are found on benches and the lower slopes of mountains, where large quantities of stones have been collected and piled in heaps and walls, and some attempt is made at cultivation. Such areas are mere patches, are worthless for cultivation, are suggestive only of wasted labor which might have been employed to better advantage elsewhere, and should be left to grow up in forest.

AGRICULTURAL METHODS.

The great possibilities of the profitable development of agricultural interests in the Champlain Valley can not be attained until the methods of farm management are greatly improved. Little care is exercised in the preparation of soils for planting. The leading soil type is the heavy Vergennes clay, which requires painstaking cultivation if the best results are to be secured, and it is extremely unfortunate that the methods of cultivation in general use are so inefficient. In April the writer saw heavy clay soil plowed when the ground was so wet that water stood in the bottom of the furrows as soon as they were turned. Plowed under such conditions the upturned furrow immediately bakes into clods which it is practically impossible to reduce before the crop must be planted. Not only this, but the bottom of the furrow, very carefully smoothed down by the plow, also bakes into a well-nigh impermeable crust which prevents the deep penetration of roots, the aeration of the soil, and the access of the root to plant food and moisture which might be available. In the spring this soil is usually too wet to plow, yet later in the season it suffers from drought. The Vergennes clay should always be plowed in the fall, and plowed deeply, leaving the surface rough for exposure to the action of frost during the winter. Moreover, the plowing should be thoroughly and carefully done. In many years there are certain periods during the autumn when the soil is so baked that it is impracticable to plow it, but the seasons are very rare, if indeed there are any, when the land may not be plowed at some convenient time during the autumn under favorable moisture conditions. During the season of this survey fields were extremely rare in which large quantities of unbroken clods were not to be seen at the time of planting, although the season was favorable for thorough preparation of the soil. These heavy clays should be worked as deeply as possible with a cutaway disk harrow until they are thoroughly mellow, but many fields are merely scratched over with a spike-toothed harrow, while others receive a semblance of preparation from a cutaway or full disk harrow, but not a single clay field was observed which had been properly prepared for planting—in other words, a field which would not have amply repaid the cost of more effective tillage by increased crop returns.

About one-half of the corn is planted by hand in check rows, so that it may be cultivated both ways. It is the usual custom to cultivate the crop twice and to hoe it by hand at least once. Corn for the silo is dropped by horse planters, and corn harvesters are rapidly coming into use. Small grain is usually sown with drills.

Hay is harvested chiefly with modern machinery, but the acreage is so large as compared with the amount of labor employed that little of it is cut as soon as ripe, and thus the quality is much impaired. Large quantities of hay are stacked in the fields, and it takes only a few years for the loss from such exposure to equal the cost of erecting a suitable hay barn.

One of the wastes observed is the almost universal custom of throwing manure from the stables into the open yard, where it accumulates in piles under the eaves. The drainage then often escapes to some near-by rivulet, and the loss entailed is enormous.

Almost no attention is paid to the rotation of crops. Corn is the chief cultivated crop, yet comparatively little of that grain is grown, hence there is little chance of rotation under the present system of farm management. The most common practice is to plow sod for oats, sowing grass seed with the oats, or else to sow oats for two years in succession, and seed with the second crop. Hay is then cut for a period rarely as short as six years, usually eight, often from ten to fifteen, and from that to fifty or even sixty years in occasional instances, before reseeding. Many farmers never reseed as long as the land will produce sufficient hay to pay for harvesting, and instances are not rare where excellent hay land has been cropped successively until it would produce only from 500 to 800 pounds of hay per acre.

A few farmers pay some attention to crop rotation, and grow corn, followed by oats, or rarely by barley, and seed. Too much stress can not be laid upon the necessity of adopting some system of crop rotation which shall involve a reseeding at least as often as once in six years. Where possible, clover should form a part of every rotation, as the increased productivity of the soil consequent upon its production will more than offset the decreased selling price of the hay for the first two years, where the hay is to be sold instead of fed on the farm; and the yield of timothy for the third and fourth years will be materially augmented. When the hay can be fed at home the advantage to be gained is even greater, because of the greater desirability of clover as a food for stock. The popular belief that corn can not be grown successfully on the stiff soils of the area owes its origin chiefly to the fact that thorough and efficient methods of tillage have not been employed.

AGRICULTURAL CONDITIONS.

As long as the center of the Merino sheep industry of the United States was in the Champlain Valley, the farmers of this area were exceptionally prosperous. Money came so easily, however, that extravagant expenditures became the rule, and when the sheep business declined the farmers failed to readjust their methods until they had lost heavily and financial ruin was staring them in the face.

The greater part of the land was owned in large tracts by men who lived on and managed their own farms. The heavy clay soils needed thorough methods of tillage, but they made excellent sheep pastures, and so were seldom plowed.

The natural adaptation of the valley soils to the production of hay, and the steadily increasing market demand for that crop as the sheep industry declined, defined at once the channel which the agricultural activities of the valley should take, and hay has been the chief money crop for many years. Under this system the agricultural possibilities of the area have remained undeveloped, but the remarkable productivity of the soils has made it easy to get a living, so that at present the farmers are fairly prosperous.

Probably less than 50 per cent of the landowners live on and till their own farms. The owner frequently occupies the farm residence and rents the land to a tenant who lives in a tenant house located on the premises. About 50 per cent of the farms are rented outright, the owner living elsewhere. The system of rental is quite variable, depending largely upon the amount of stock furnished by the tenant, but by the most common arrangement the tenant receives half the income and half the increase in stock. The opportunities to farm profitably are so good that the tenant, if he be a good farmer, can do well under this system.

Farms range in size from 50 to 500 acres, but there are few at either extreme. Most of them include from 200 to 250 acres. The price of land ranges from $15 to $40 an acre, but good farms with suitable buildings, on the level Vergennes clay, can be bought for $20 to $25 an acre, and at this price such farms offer to intelligent farmers unsurpassed opportunities for lucrative farming.

The scarcity of labor becomes a more serious problem each year, and this is the cause generally assigned for the renting of so many farms, and also for the absence of more intensive methods of farming. Wages range from $22 to $25 a month, with board, for eight months of the year, and not enough capable men can be obtained at this price.

The principal products are hay, butter, and cheese; while the products of lesser importance are lambs, wool, beef, pork, and apples. The hay is of excellent quality, and enormous quantities are sold. Alfalfa has been grown successfully in several places. One farmer has 4 acres on the Vergennes fine sand, and the same amount on heavy Vergennes clay. This has been mowed three times a year since the first year, when two crops were obtained. The average yearly yield, with three cuttings, has been nearly 4 tons per acre. Such experiments have demonstrated that this valuable crop may be grown on most of the soils of the area where drainage is well established, by those willing to prepare the land thoroughly and to exercise the proper precautions in the care of the crop. The seed should be sown in the spring, as soon as the soil can be put in good condition.

The principal part of the milk produced is hauled to proprietary creameries, daily during the summer and two or three times a week during the winter. It is unfortunate that so little milk is produced during the winter when prices are the highest. Until recently winter dairying was almost unheard of. It is gradually increasing, however, and many silos have been built within the last five years. The opportunities for winter dairying are unexcelled, and just as soon as the land is divided into smaller farms and more intensive methods are adopted the Champlain Valley will be able to compete successfully with any other section of the country in the production of butter. It should be said in this connection that much closer attention should be given to the improvement of dairy herds.

The undeveloped condition of the dairy interests has made necessary and advantageous the inauguration of the system of proprietary creameries, but there is much dissatisfaction with the way in which they are managed. A cooperative creamery at Crown Point is very successful at the present time, and as the dairy interests increase the cream will undoubtedly be sold by this method, which has been so successful in many places. Some of the creameries make cheese as well as butter, but this practice seems to be decreasing.

Lambs are marketed from the last of June until September. No attempt is made to produce early lambs, and with the present methods this business could hardly be successful. Steers 2 and 3 years old are sold from the pasture late in summer. Nearly every farmer produces pork for home use and sells a few fat hogs each year.

Fruit has received little attention, but there are a few large young orchards, and interest in this industry is growing.

Little attention is paid to the adaptation of soils to crops. Hay is the principal crop on all soils which are plowed at all, and small grain usually follows for seeding. The light soils are sought for potatoes and corn.

The transportation facilities on the New York side are good, as a line of railway to New York City follows the general course of Lake Champlain the entire length of the area. In Vermont a line to Boston passes through the northeast corner of the area at Vergennes. The Addison Branch crosses the southern part of the area and connects these main lines. This leaves a large part of the section along the east side of Lake Champlain 10 miles or more from a railway.

The dirt roads on the Vergennes clay, though excellent when smooth, rut deeply when wet, and upon drying bake into clods like bricks. In this condition the roads are so rough that it is practically impossible to drive faster than a walk, and riding at that rate is very uncomfortable. Often the roads are not worn smooth before the next rain, and then the same process of gradual wearing down has to be repeated. There is an excellent opportunity for the building of an electric railway, if a freight-carrying franchise were secured, to extend from Vergennes through Panton, Bridport, Shoreham, and Orwell to the south, and its construction would be of inestimable benefit to the agricultural interests of the valley.

On the Vermont side Boston is the principal market for hay, cattle, sheep, butter, and cheese, though the latter two are shipped also to Portland, Me., Providence, R. I., and Springfield, Mass. Hay and cattle are shipped also to New York, Springfield, Mass., and Hartford, Conn. On the New York side nearly all products are shipped to Albany, Troy, and New York City.

SOIL SURVEY OF THE AUBURN AREA, NEW YORK.

By **J. E. LAPHAM** and **HUGH H. BENNETT.**

LOCATION AND BOUNDARIES OF THE AREA.

The Auburn area is situated in the central western part of New York State, about half way between Buffalo and Albany, and about 25 miles south of Lake Ontario. The area includes all of Cayuga County south of parallel 43° N., which passes about half a mile north of the village of Sennett. The eastern boundary is formed by Onondaga and Cortland counties; the southern by Tompkins County, and the western by Seneca County. The area is 26 miles long from north to south, and 14 miles wide at the north end. About 11 miles south of the forty-third parallel the county offsets at right angles 4 miles to the east, and thence southeast for a distance of 8 miles Skaneateles Lake forms the boundary between Cayuga and Onon-

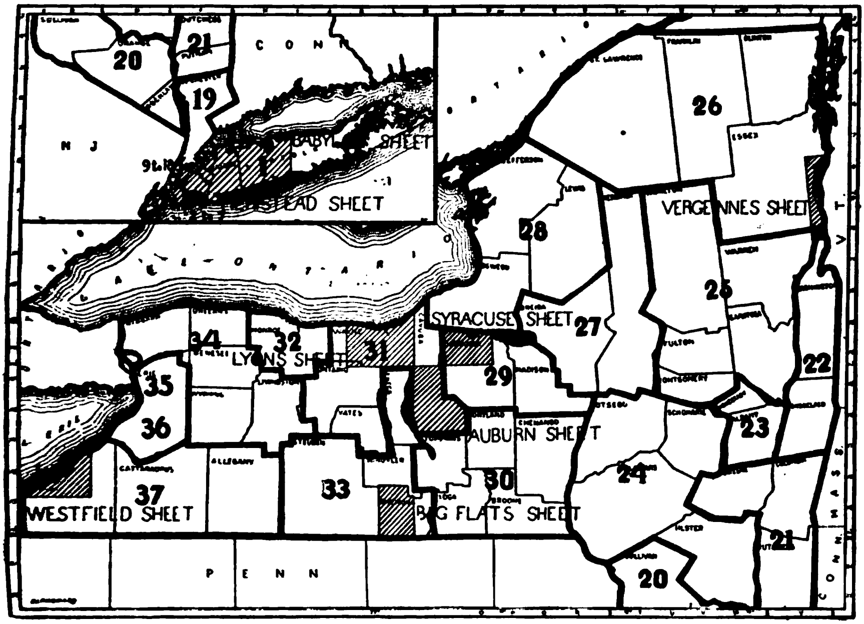

FIG. 2.—Sketch map showing location of the Auburn area, New York.

daga counties. The western boundary throughout the whole distance is formed by Cayuga Lake and 4 miles of the Montezuma Marsh at the lower end of the lake. The average width of the central and southern half of the county is about 22 miles.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

It was not until after the close of the Revolutionary war that Cayuga County was first settled. In 1789 all western New York was called Montgomery County. This county was subdivided, and what is now Cayuga County was then included in Batavia Township. Herkimer County was formed from Montgomery in 1791, and in 1794 was redivided and the territory under present consideration came into Onondaga County. Cayuga County was formed from Onondaga in 1799.

The first white settler in Cayuga County came to Aurora in 1789, when the territory was known as the Onondaga military tract, which had been surveyed into lots to satisfy the bounty claims of the veterans of the Revolutionary and border wars, each private of which was to receive one of these lots of 500 acres. In 1793 Capt. John L. Hardenburgh secured one of these lots located on Owasco Outlet, at the present site of Auburn. The Outlet was crossed at this point by an Indian trail, which later developed into the thoroughfare known as the Genesee road. Hardenburgh brought with him besides his family two negro slaves, and with their help began the clearing of a patch of land on his new claim and the erection of a gristmill, which had a daily capacity of 12 bushels of wheat. Other settlers soon began to be attracted to what was for many years known as Hardenburghs Corners. In three or four years a schoolhouse was built, and following this another gristmill.

Among the first white people to come to Hardenburghs Corners were several families from Gettysburg, Pa. The greater proportion of the settlers, however, came from the eastern part of the State and from Massachusetts and Connecticut, where the richness of the lands of the Onondaga military tract was already well known.

The development of the country was hindered to some extent by the lack of transportation. The roads were merely widened Indian trails, and the one passing through the Corners for many years held the reputation of being the worst in the western part of the State. Stages were running in 1800, with semiweekly mails, and two or three years later the Genesee road, or Seneca turnpike, was constructed, and for many years was the principal channel of trade across the State. Large numbers of settlers located along this road wherever they were able to secure desirable lands. One of the early modes of travel from Cayuga Lake to Utica and Schenectady was by boat, or bateau, through the Mohawk, Seneca, and other connected rivers. The trip from Schenectady to Seneca Lake could be made in from fifteen to twenty days with 1½ tons of goods. By 1820 the Grand Canal was so far completed that boats ran from Montezuma, the port for Cayuga County, to Utica in two days, and in another year the packet boats were able to go through to Schenectady. The canal, now called the Erie Canal, was finally completed in 1825, furnishing relatively cheap though slow transportation to the East for the rapidly increasing volume of farm produce.

The first track, made of wood, of the Auburn and Syracuse Railroad was laid in 1838, and for the first year the cars were drawn by horses. This equipment was superseded in 1839 by iron rails and locomotives. The Auburn and Rochester Railroad was completed into Auburn in 1841, and a few years later the two roads were consolidated into the New York Central. The Southern Central Railroad was opened from Fair Haven to Sayre, Pa., in 1869, and what later became another branch of the Lehigh Valley Railroad, from Auburn to Ithaca, was completed in 1873.

The agricultural population of Cayuga County increased rapidly from the first, and in 1800 it had reached 15,000, while Auburn, the chief town, had only a few hundred inhabitants. An agricultural society was organized and a fair held in the county as early as 1818, and from the fact that these fairs were, with few interruptions, held annually for many years, it may be judged that the settlers were alive to the desirability of improving the quality of their products, to the adoption of new methods, machinery, etc., and that they gladly welcomed these mutually profitable yearly exhibitions. Save for the interruption and unusual hardships entailed by the civil war, the prosperity of the farming population has remained unchecked from the time of the establishment of adequate railroad and canal communication with the outside world to the present time.

CLIMATE.

The climate of the Auburn area is characterized by long, cold winters and correspondingly short summers. The rainfall is well distributed throughout the growing season, and while the summer temperature seldom reaches 90° F., all of the ordinary farm crops produced north of Maryland can be profitably grown in this climate.

The following table shows the average temperature and the amount and distribution of precipitation throughout the year:

Normal monthly and annual temperature and precipitation.

Month.	Auburn.		Baldwinsville.		Romulus.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	° *F.*	*In.*	° *F.*	*In.*	° *F.*	*In.*
January	24.1	2.59	22.5	3.32	24.4	2.18
February	24.9	2.16	23.6	3.38	23.9	2.05
March	32.8	2.28	30.4	3.71	32.7	2.55
April	45.5	2.87	44.4	2.22	46.4	2.14
May	56.5	3.54	56.2	3.62	57.7	3.99
June	65.8	3.85	65.6	3.36	67.7	3.13
July	70.6	3.69	70.3	4.18	67.2	....
August	69.0	3.44	67.7	3.41	70.0	3.16
September	60.9	3.10	61.1	3.21	62.7	2.83
October	49.7	3.38	49.4	3.05	51.3	3.02
November	38.5	4.24	38.3	3.51	39.6	2.90
December	29.2	2.82	28.3	3.81	29.5	2.53
Year	47.3	37.46	46.5	40.73	47.8	....

PHYSIOGRAPHY AND GEOLOGY.

The physiography of the northern part of the area is characterized by the presence of many glacial hills, or drumlins. These hills lie parallel in a general direction (N. 18° W.), and usually show the lenticular, drumlinoid form—long and narrow. Their length ranges from one-fourth of a mile to 1 mile, the width is about one-third of the length, and the height ranges from 20 to 120 feet at the highest part of the hill, which is usually about one-third of the distance back from the northern end. The northern ends of these hills are quite abrupt, and many of them possess a pronounced shoulder, or bench, near the top. The southern ends slope away at a very gentle angle, some of them measuring only about 1° and gradually disappearing until the level of the surrounding plain is reached. The sides are in most instances quite steep, showing an angle usually somewhat steeper than that of the northern end. A glance at the map shows the influence of these parallel, interlocking hills upon the laying out of the roads, nearly all of which are naturally forced to follow the general trend of the drumlins, with few connecting crossroads. The hollows and depressions intervening between these hills follow, as a rule, quite straight corresponding lines, and in these are located the swamps and streams, with the drainage uniformly toward the north.

South of a line from Cayuga to Auburn these abrupt hills disappear and give place to a rolling topography exhibiting smoother contours, and, with the exception of a few outlying drumlins, showing none of the uniformity of conformation and direction just described. This area occupies a position between the northern ends of Owasco and Cayuga lakes, and forms a kind of basin between the drumlin area and the gradually rising plateau to the south. The drainage of this basin is partly northward into Owasco Outlet and Crane Brook, and partly westward into Cayuga Lake. It is upon this type of topography that the Dunkirk clay loam is best developed.

East of Auburn the drumlin topography persists a little farther to the south, although somewhat interrupted along the Franklin Street road, disappearing again before reaching Dutch Hollow Brook. Southward from the northern end of Owasco Lake, on both sides, the country rises more rapidly and uniformly, forming high, rounded table-lands, or plateaus. The long, narrow, parallel lakes—Cayuga, Owasco, and Skaneateles—constitute the chief physiographic feature of the Auburn area. The plateau on the east side of Owasco Lake reaches its maximum elevation of 1,840 feet in Sempronius Township, and on the west side of the lake an elevation of 1,400 feet is attained in Venice Township. From these points there is a gentle slope southward to the Tompkins County line and northward to Lake Ontario.

Into the plateau between Owasco and Cayuga lakes the main branch of Salmon Creek has eroded a comparatively steep-sided valley, which is 200 feet deep at Venice Center, and 400 feet deep 8 miles farther south, at the county line. A smaller, but quite deep, valley is also cut by little Salmon Creek, the course of which runs nearly parallel to the main stream and is 5 miles long, the two valleys coalescing about a mile north of the county line.

The eastern plateau, lying between Owasco and Skaneateles lakes, is divided into three parts. Dutch Hollow Brook, rising near Kelloggsville and flowing northwest into the lower end of Owasco Lake, and Dutch Creek, rising about 2 miles east of Omro and flowing southwest through a continuation of the same ancient valley into the upper end of Owasco Lake, separate two of these divisions, the other boundaries of which are formed by Owasco and Skaneateles lakes. The third division is separated from the other two by Montville Creek, rising near Dresserville and emptying into Owasco Inlet near Moravia, and Fall Creek, heading near North Summer Hill, gaining accessions in Lake Como, and passing out of the southeast corner of the county. These latter two creeks, like Dutch Hollow Brook and Dutch Creek, take opposite directions in the trough of a common preglacial valley. Besides these valleys, Owasco Inlet and its principal tributary, Stony Creek, together form a triangular area of about 6 square miles, which reaches at the county line a maximum height of 500 feet above the stream beds. All of these deep valleys in the two plateaus are filled to depths ranging from 20 to 100 feet or more with glacial moraine. This morainic material along most of the streams influences the soil to a marked extent. To this cause is due the band of Miami stony loam along the Owasco Inlet and Big and Little Salmon creeks, and also along Montville Creek emptying at Moravia.

These plateaus have their highest elevations, as well as their steepest slopes toward the lakes, along the southern ends of the easterly escarpments. The western plateau has a slope, north of Wykoffs, of only about 200 feet to the mile, which gradually increases until, at the head of Owasco Lake, it is nearly 500 feet to the mile. Opposite Moravia it becomes quite precipitous, rising to a height of 700 feet above the valley in a horizontal distance of little more than half a mile. This mountainous slope is maintained to the southward for several miles, while across the valley on the west slope of the eastern plateau the inclination is not greater than 500 feet to the mile. The eastern escarpment of this plateau, at Glenhaven, situated at the upper end of Skaneateles Lake, exhibits about the same declivity as the one opposite Moravia, but the relative elevation is somewhat greater, the crest of the escarpment being about 950 feet above the lake.

The slope of the plateau along Cayuga Lake also gradually increases to the southward, ranging from about 200 feet to the mile at Union Springs to 500 at the southern boundary line. Streams from half a mile to 2 or 3 miles in length flow off these slopes into the lakes at from one-fourth of a mile to 1 mile apart, forming sometimes deep, rocky gorges 200 or 300 feet in depth and thickly forested with oak, hickory, elm, maple, and other hardwood trees, among which is a scattering of hemlock.

The underlying rocks of the area consist for the most part of limestones and shales, and range from the Upper Silurian, covered by the glacial drift of the northern part of the area, to the more recent rocks of the later Devonian, found in the southern part of the county. There are probably no considerable areas of residual soil, it being all influenced to a greater or less extent by the grinding, mixing, and transporting action of the glaciers which once covered this portion of New York State. A large part of the transported stone present, especially in the northern part of the area, consists of the rounded fragments of crystalline rocks, which have been brought long distances from the north. Mixed with these are many fragments of limestone and shale which have not been carried far from their original position. In the southern and south-central parts of the county these fragments give little evidence of glacial action, and are quite sharp and angular. The Volusia loam in some portions of Sempronius, Summer Hill, Moravia, and Locke townships is largely the product of residual weathering of Hamilton and Genesee shales, and has been reworked comparatively little by glacial action. Along the walls of such valleys as the one south of Moravia, the valley of Montville Creek, and the Salmon Creek valleys, large amounts of glacial débris have been deposited as moraines, and the influence of the native rock is less apparent in the soil formation.

SOILS.

Exclusive of Meadow and a few small areas of Muck, nine types of soil have been recognized and mapped in the Auburn area. The following table shows the actual and relative extent of each type:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Miami stony loam	114,624	38.9	Dunkirk clay	2,880	1.0
Volusia loam	70,720	24.0	Miami fine sand	1,920	.6
Dunkirk loam	50,304	17.1	Dunkirk gravelly loam	640	.2
Dunkirk clay loam	35,584	12.1	Muck	512	.1
Meadow	8,000	2.7	Total	294,976	
Miami loam	5,696	1.9			
Dunkirk stony clay	4,096	1.4			

MIAMI STONY LOAM.

The soil of the Miami stony loam, to an average depth of about 9 inches, is a brown or grayish-brown loam, containing about 35 per cent of the various grades of sand and some small gravel. Upon drying after a rain the surface is firm and compact, often hard, yet it does not form troublesome clods in cultivation. The surface is covered with from 20 to 50 per cent of stones, ranging from 1 to 5 inches in diameter. Many of these are fragments of crystalline rocks, which were well rounded during their transportation by the glaciers. There are also present some pieces of flat and partially rounded shale and limestone, which have been transported comparatively short distances. The quantity of stone at the surface interferes to some extent with cultivation.

The subsoil is a compact loam, slightly sandy, and usually light-brown in color, though sometimes grayish brown and mottled. In some localities small pockets of fine gray sand are present, together with minute chips of drab shale. The percentage of stones is usually less than in the soil, owing to the tendency of frequent washing and cultivation to leave them exposed at the surface.

The Miami stony loam mapped south of Auburn, on both sides of Owasco Lake, is generally more sandy and as a rule a little less stony in character than is the case with the thicker glacial deposits to the north. This type is found best developed in the northern part of the area, though it has been quite extensively mapped southeast of Auburn, in Niles Township, and southwest, in Ledyard, Venice, and Genoa townships. In the former instance it occupies the glacial hills and the well-drained intervening depressions, and in the latter the table-lands or plateaus between the parallel lakes. The glacial hills are, for the most part, long and narrow and rise in height from 20 to 200 feet above the surrounding country. Their sides are in some instances too steep for cultivation, and upon the tops of some of the narrower, steeper ones erosion has exposed the underlying glacial till. The slope of the Miami stony loam occupying the plateaus is more gentle, rendering transportation easier and cultivation less difficult.

The topography of the type, combined with the natural porosity of the soil and subsoil, insures sufficient drainage in most instances without resort to artificial means. A few depressions between the glacial hills, however, require to be ditched.

The soil is for the most part derived from the weathering of the material left behind after the retreat of the glaciers, although in the central and southern parts of the area it is probably more or less reworked and intermixed with residual soil.

Upon this type of soil nearly all of the ordinary farm crops give fair results. Among the glacial hills its use for crops requiring much cultivation is limited on account of the naturally rough topography on some of the steeper-sided drumlins, and it is here better adapted to grazing and for hay.

Corn, oats, potatoes, barley, and to some extent buckwheat, are grown upon the Miami stony loam. Grass, also, is given quite a large acreage, though the yield is not so great as upon the heavier types of soil, from 1 to 2 tons of hay being a good average. Corn produces about 35 bushels per acre under good conditions. Sixty bushels is a fair crop of oats, while potatoes yield from 50 to 150. Wheat receives comparatively little attention, though 25 bushels an acre is not an uncommon yield. Fruit does well on this type, and apples, pears, cherries, and other kinds are grown.

The following table shows the results of mechanical analyses of the fine earth of this type:

Mechanical analyses of Miami stony loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11738	2¼ miles S. of Genoa.	Brown loam, 0 to 8 inches.	2.6	4.5	2.8	11.4	20.9	40.1	17.9
11736	¾ mile S. of Austin ..	Brown loam, 0 to 10 inches	2.4	4.0	3.1	10.8	19.0	41.7	19.3
11407	¾ mile E. of Throop .	Brown heavy loam, 0 to 10 inches.	.5	1.9	2.6	16.8	12.0	34.0	32.1
11739	Subsoil of 11738	Yellow loam, 8 to 30 inches	2.9	4.7	3.2	11.5	18.9	40.8	17.9
11737	Subsoil of 11736	Brown loam, 10 to 36 inches.	2.4	6.5	3.6	11.1	19.0	33.0	24.4
11408	Subsoil of 11407	Light-brown clay, 10 to 36 inches.	Tr.	1.5	1.5	9.2	6.6	40.1	40.5

DUNKIRK CLAY LOAM.

The soil of the Dunkirk clay loam is a dark-brown to grayish-brown clay loam extending to a depth of 8 inches. It contains considerable silt and a small amount of fine sand, but is quite stiff and heavy, often exhibiting many cracks at the surface after rains. In many localities large stiff clods are turned up by the plow and are with much difficulty broken and crumbled by the harrow and roller. As a rule the surface is quite free from stone, although from 5 to 15 per cent is sometimes found in local spots. The subsoil is a mottled brown and gray heavy clay loam or clay. The gray mottling is usually due to small, irregularly distributed lumps of thoroughly decomposed shale. The subsoil is mostly free from stone or gravel.

With the exception of a strip of land bordering Cayuga Lake, the Dunkirk clay loam is confined to the northern third of the area surveyed. The areas are generally connected and fairly uniform, though interrupted here and there by spots of the Dunkirk clay, Meadow, and Miami stony loam. Its best development is upon the gently undulating topography occurring just south of the glacial hills, though it is also found to quite an extent in the depressions between the southernmost of these hills. Along the shore of Cayuga Lake the type has fewer depressions, but slopes, sometimes gradually, sometimes abruptly, toward the lake. The drainage in the latter-mentioned locality is nearly always good, but in the less sloping or in depressed areas it is often necessary to resort to artificial means. On account of its heavy compact nature and the general absence of stone, the subsoil is almost impervious to water.

The Dunkirk clay loam was probably formed from a mixture of the finer sediments washed out at the front of the glacier and those brought down from the south. It is believed that these sediments were all reworked and intermixed with more or less material derived directly from weathering of the underlying limestone and shale, and deposited in pondlike depressions at the foot of the glacier during its retreat, and while it still partially blocked the way of escape of waters to the north.

The type is well adapted to the production of wheat and grass. Corn also does well, but the task of cultivation is greater than upon some of the other types. It is in demand for general farm crops, and produces good yields of nearly all crops requiring a heavy soil. Wheat yields about 25 bushels and grass from 1½ to 3 tons per acre. Timothy and clover are the grasses most extensively grown, though alfalfa has met with fair success in some localities. Grapes do well upon this type, and also peaches, where the trees are not killed by the severe winters.

The following table gives the results of mechanical analyses of the soil and subsoil of the Dunkirk clay loam:

Mechanical analyses of Dunkirk clay loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11729	5 miles SE. of Aurora	Brown clay loam, 0 to 8 inches.	2.2	2.6	2.3	10.3	17.4	36.0	29.0
11405	1 mile N. of Levanna.	Clay loam, 0 to 9 inches..	2.4	3.8	3.4	15.0	10.8	35.1	29.4
11730	Subsoil of 11729......	Heavy clay loam, 8 to 30 inches.	1.4	3.3	2.2	8.9	14.9	36.3	32.3
11406	Subsoil of 11405......	Brown clay, 9 to 36 inches.	3.2	4.6	3.2	10.0	10.1	31.6	36.9

DUNKIRK LOAM.

To an average depth of 10 inches the soil of the Dunkirk loam is a light or dark-brown loam, sometimes slightly heavy and clayey. Generally, however, it contains considerable fine and very fine sand, which renders it friable, mellow, and easily cultivated. It seldom clods under cultivation, and, as a rule, there is not enough stone present (5 to 20 per cent) to interfere with tillage.

From 10 to 20 inches the subsoil is a yellow or light-brown fine sandy loam, usually rather compact, but sometimes only moderately coherent. Below 20 inches the subsoil becomes darker in color and heavier in structure, though sometimes containing small pockets of fine sand at irregular depths. The quantity of stone rather exceeds that in the soil, and in some parts of the county it is sufficient at 18 or 20 inches to interfere seriously with boring. These stones are small in size, seldom exceeding 2 or 3 inches in diameter, while the greater proportion ranges from small gravel to a little over an inch in diameter.

The Dunkirk loam occupies a large and continuous area south of the latitude of Auburn and west of Owasco Lake, and includes the larger part of Scipio Township, as well as a number of square miles in Fleming and Ledyard townships. Only one or two small areas have been mapped east of Owasco Lake.

The topography of the type is characterized by gentle undulations, with no considerable hills or deep valleys. In Venice and Genoa townships the topography is quite similar to that of contiguous areas of the Miami stony loam, and considerable difficulty was experienced in separating the two types. In most places adequate natural drainage is secured by the rolling topography, aided by the porosity of the subsoil.

The Dunkirk loam was derived from glacial material in much the same manner as the Miami stony loam. The material, however, was more sandy in character and contained considerably less clay. It is probably in part reworked with residual soil derived from sandstone or arenaceous shale.

On account of its slightly sandy nature and the comparative ease with which it can be tilled, this is a desirable type of soil for general farm purposes. Its relative earliness in the spring, good drainage, and comparative freedom from stone make it well adapted to corn, potatoes, and most vegetables needing a friable, easily cultivated soil.

Corn, oats, potatoes, buckwheat, and barley are the principal crops. Corn yields from 30 to 50 bushels, oats 40 bushels, barley 30 to 40 bushels, and buckwheat 20 bushels or more per acre. Potatoes of good, smooth quality are produced at the rate of from 75 to 200 bushels per acre. Fruit, especially apples and pears, does well on this type.

The following table shows the results of mechanical analyses of the fine earth of the soil and subsoil of this type:

Mechanical analyses of Dunkirk loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11723	3¼ miles E. of Ledyard.	Dark-brown loam, 0 to 9 inches.	0.8	2.6	2.8	14.6	15.7	52.0	11.12
11725	3 miles E. of Aurora.	Dark-brown loam, 0 to 9 inches.	1.4	3.1	3.5	17.4	21.1	39.6	13.6
11724	Subsoil of 11723	Loam, 9 to 30 inches	1.5	4.8	4.0	16.8	16.6	43.4	12.6
11726	Subsoil of 11725	Fine sandy loam, 9 to 24 inches.	3.4	4.2	3.8	13.8	24.7	33.2	16.8

VOLUSIA LOAM.

The soil of the Volusia loam is usually a smooth, uniform loam, containing considerable silt, with a depth of 7 inches. There are often present a great many minute chips of partially decomposed shale, which, upon a rain-washed surface, give to the soil a gravelly appearance. The color is usually a yellow or light brown, though in some localities it is a dark brown, owing to the higher content of organic matter. The surface is strewn with from 20 to 75 per cent of irregular, angular, flat pieces of shale, together with a few small, rounded, glacially transported stones. The shale fragments are frequently a square foot in area and 2 or 3 inches thick, and so numerous as to afford abundant material for fences.

The subsoil is a heavy, compact loam, also quite silty, the texture of which is about the same as that of the soil, except that it contains a rather larger quantity of fine shale chips. The rock fragments of various sizes are so numerous in the subsoil that it is difficult to bore into it below 24 inches.

The Volusia loam is found to the greatest extent in the southern part of the county, where it occurs in a large and continuous area of nearly 100 square miles. It occupies a high upland plateau reaching a maximum elevation of a little over 1,800 feet. Into this the old valleys of Skaneateles and Owasco lakes and their inlets have cut to a depth of from 400 to 900 feet. The surface is gently rolling over most of the plateau, with steep sides along the western edges of Skaneateles and Owasco valleys.

The surface drainage is for the most part adequate, though in some places water runs out of the joints between the shales and forms wet areas, which are soon covered with water-loving grasses and trees. In Summer Hill Township there are a number of these hanging meadows on hillsides where the slope would ordinarily be ample for the complete drainage of all surface water.

This soil is the product of the weathering of the underlying shale and limestone, this later being mixed with a small percentage of glacial material.

The Volusia loam is adapted to most of the ordinary farm crops where the shale fragments are not so numerous as to interfere seriously with cultivation. Hay produces well, and it is recommended that dairying be more extensively developed on this type of soil. Fruit does well, and it is believed that grapes would prove a profitable crop on many of the shale-loam slopes.

Corn, barley, buckwheat, potatoes, oats, and grass are the principal crops grown. Grass is given the largest acreage, and next to this probably buckwheat. The former yields from 1½ to 2½ tons, while buckwheat produces from 20 to 25 bushels per acre. Potatoes average about 75 bushels; oats, 50 bushels, and barley, 30 bushels.

The following table gives the results of mechanical analyses of the fine earth of typical samples of the Volusia loam:

Mechanical analyses of Volusia loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11731	¼ mile SW. of Summer Hill.	Brown loam, 0 to 6 inches.	2.3	6.1	4.1	11.8	15.0	39.1	21.0
11733	1¼ miles E. of Austin.	Yellow clay loam, 0 to 7 inches.	1.0	2.6	1.6	5.8	9.1	44.5	35.1
11732	Subsoil of 11731	Loam, 6 to 18 inches	2.4	7.4	4.6	12.1	15.5	40.8	16.8
11734	Subsoil of 11733	Clay loam, 7 to 30 inches	1.3	4.4	2.9	8.5	11.7	44.3	26.9

DUNKIRK STONY CLAY.

The soil of the Dunkirk stony clay, to a depth of 8 or 10 inches, is a yellow or gray silty clay loam, which becomes quite compact at the surface and often exhibits sun cracks. From 10 to 20 per cent of rounded and angular stones occur in the surface foot. The greater proportion of these are small fragments ranging from one-fourth inch to 1 inch in diameter, though some as large as 3 inches in diameter are scattered through the soil mass. The subsoil to a depth of 3 feet or more is a solid, stiff mass of brown, yellowish-brown, or mottled clay, which becomes very sticky and plastic when wet. The stone content of the subsoil is greater than that of the soil.

The Dunkirk stony clay is found along the east shore of Cayuga Lake, south of Aurora, and extends into Tompkins County, where it is most typically and extensively developed. The surface is usually steeply to gently sloping, and the erosion is characterized by a series of parallel gullies and ridges which are rounded rather than angular in cross section. At the maximum elevation—about 980 feet along Cayuga Lake—the surface is rather flat and the soil deeper, the gullies gradually deepening and the soil on the intervening ridges thinning as the lake is approached at the foot of the slope.

Though there is usually sufficient slope for surface drainage, the underdrainage is retarded by the very compact nature of the subsoil, so that ditching and tiling are necessary to secure the best results. On account of the comparatively impervious character of the soil some erosion attends heavy rains.

From the uniform height at which its maximum elevation is attained and its association with gravelly delta deposits, as well as the laminated structure of the subsoil, as observed in the Tompkins County area, it is believed that the Dunkirk stony clay is an old lake sediment, the deposition of which commenced when the lake was at a much higher level than it is at present.

This is the best type of soil in the area for grapes, which do very well under the favorable climatic conditions along the immediate lake shore and for a distance of half a mile or so inland—300 or 400 feet above the level of the lake. Pears and apples also do well. Of the ordinary farm crops wheat and grass are among those most profitably grown. Wheat yields on an average from 20 to 30 bushels to the acre and hay 1½ to 3 tons. Grapes produce about 4 tons to the acre, the Concord, Niagara, and Delaware being the favorite varieties.

The following table gives the results of mechanical analyses of the fine earth of the soil and subsoil of this type:

Mechanical analyses of Dunkirk stony clay.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11721	½ mile E. of Atwater.	Yellow silty clay, 0 to 10 inches.	2.1	4.6	2.6	10.4	13.8	41.8	24.6
11722	Subsoil of 11721	Yellow clay, 10 to 30 inches.	3.0	5.1	2.7	8.5	10.1	35.3	35.1

DUNKIRK CLAY.

The soil of the Dunkirk clay is a heavy, brownish-gray clay loam extending to a depth of 9 inches. It is quite close and compact, and is not easily cultivated. The soil does not dry out until late in the spring, and early plowing always results in the formation of troublesome clods. There is seldom any stone at the surface or in the subsoil, except in a few instances where it borders the Miami stony loam. The subsoil, to a depth of 36 inches, is a uniformly mottled gray, brown, and yellow clay. In a few instances quicksand has been observed at a depth of 20 inches or more.

The Dunkirk clay is confined almost entirely to the northern third of the area surveyed, though a few spots occur irregularly in other parts of the county. It occupies flat or only slightly undulating positions, and is generally found in depressions occurring in areas of the Dunkirk clay loam or the Miami stony loam, and along the margins of swamps. It is necessary to resort to artificial means to secure drainage of this type, and this is often difficult, for the fall to natural outlets is usually slight.

This soil is derived from the finer sediments which have been washed down from the surrounding upland and deposited under water.

The Dunkirk clay, on account of its inadequate drainage, the impossibility of preparing it for early spring crops, and the difficulties of tillage, is best adapted to grass, and it is to this crop that the areas of this type are principally devoted. Hay yields from 2 to 3 tons to the acre. Corn is grown to some extent upon the highest, best drained portions of the type, and produces from 20 to 40 bushels per acre.

The following table shows the results of mechanical analyses of typical samples of the Dunkirk clay:

Mechanical analyses of Dunkirk clay.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11717	¼ mile N. of Moravia.	Brown clay loam, 0 to 7 inches.	0.3	1.0	0.8	3.5	3.8	59.8	30.7
11719	¼ mile SE. of Throopsville.	Heavy clay loam, 0 to 8 inches.	2.1	4.3	2.5	9.7	7.9	39.3	34.0
11718	Subsoil of 11717	Mottled clay, 7 to 36 inches.	.0	.2	.2	1.4	6.9	54.3	36.9
11720	Subsoil of 11719	Brown heavy clay, 8 to 36 inches.	.7	2.2	2.1	8.3	8.1	37.0	41.2

DUNKIRK GRAVELLY LOAM.

To a depth of 10 inches the soil of the Dunkirk gravelly loam is a dark-brown loam, containing from 20 to 50 per cent of rounded glacial gravel from one-fourth of an inch to 3 inches in diameter. The soil is mellow and easily tilled, the stones seldom being large or numerous enough to offer much resistance to the plow or cultivator. The subsoil to 36 inches is a heavier brown loam, containing from 30 to 60 per cent of gravel, so that boring below 20 inches is usually impossible.

This type of soil has been mapped in but two places in the area—one a mile northeast of Moravia, and the other south of Locke. It occupies distinct and nearly flat-topped terraces, having a depth of about 100 feet to the beds of the streams which have formed them. There is sufficient surface slope, combined with the open, porous condition of the subsoil, to furnish adequate natural drainage.

This soil is derived from glacial and residual material brought down by the confluent streams and deposited at their junction. The soil thus formed is added to by more or less wash direct from the adjacent upland. This work of deposition was in progress long ago, when the streams were at a much higher level, and is going on to a less extent at the present time.

When the seasons are not too dry this type is particularly well adapted to corn, and it should also prove an excellent soil for grapes and small fruit. Corn yields from 50 to 70 bushels, and oats about 50 bushels per acre.

The following table gives the results of mechanical analyses of the fine earth of both soil and subsoil of this type:

Mechanical analyses of Dunkirk gravelly loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11752	1½ miles NE. of Moravia.	Brown loam, 0 to 10 inches.	7.1	9.2	4.6	10.0	8.5	39.3	21.1
11753	Subsoil of 11752......	Brown loam, 10 to 30 inches.	7.2	9.3	5.6	13.6	10.1	36.5	17.6

MIAMI FINE SAND.

The Miami fine sand as mapped in this area varies somewhat in topography, soil structure, and drainage features, according to its location.

On the rolling hills and where the topography is rough and broken, the soil, to an average depth of about 12 inches, consists of a yellowish-brown fine sand, usually loose and mellow, and inclined to be incoherent, though in some instances in the depressions it may be somewhat loamy, but never compact. The underlying subsoil is a fine incoherent orange sand to a depth of 3 feet or more. Seldom any stone is found in either soil or subsoil. Owing to the natural porosity of both soil and subsoil and the rolling topography of such areas artificial drainage is seldom necessary.

Another phase of the type in the glacial hill country in the northern part of the area occupies flat and only slightly rolling areas, usually along the margins of swamps or streams. Here the soil to a depth of 10 inches is a brown fine sandy loam, somewhat silty in texture, and free from stone and gravel. The subsoil is a yellowish or grayish fine sand, which at about 18 inches usually becomes quite compact and resembles a hardpan. This condition persists for from 4 to 10 inches, and is succeeded by a fine incoherent yellow sand partaking in some localities of the characteristics of a quicksand. In these low-lying areas the natural drainage is not sufficient for the needs of most crops. The mechanical difficulties of excavation are not great, however, and the work of ditching where there is enough fall is less expensive than upon many of the other types of soil.

The Miami fine sand is of glacial origin, the soil being formed as the result of deposition. In the low flat areas the soil is derived from the materials deposited by streams and glacial waters, and to the assorting power of stream action is due the uniform texture of the soil.

The type as a whole is not well adapted to general farming like some of the heavier soils. Its best usefulness has been found in the growing of the early special crops and vegetables. It is not much used for the ordinary farm crops, but near Auburn it is used to some extent for market gardening. A considerable portion of the hilly phase of the type northeast of Auburn is still in forest, the growth being principally beech and maple. The low-lying areas are devoted largely to grazing and to the production of hay, but if well drained would be suited to corn, potatoes, and garden vegetables.

The following table gives the results of mechanical analyses of typical samples of both soil and subsoil of the Miami fine sand:

Mechanical analyses of Miami fine sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11744	1 mile W. of Auburn.	Brown fine sand, 0 to 12 inches.	0.1	1.1	4.8	58.4	24.7	6.3	4.5
11742	3 miles E. of Auburn.	Brown fine sand, 0 to 8 inches.	.1	1.5	4.8	58.0	24.6	5.6	5.3
11748	1 mile SE. of Throopsville.	Fine sandy loam, 0 to 15 inches.	.3	.6	.8	38.9	36.4	16.9	5.8
11746	2 miles SE. of Auburn	Fine sandy loam, 0 to 12 inches.	1.2	2.7	3.8	31.2	36.0	14.4	10.4
11743	Subsoil of 11742	Fine sand, 8 to 36 inches.	.1	.9	3.6	66.6	25.1	1.6	2.1
11749	Subsoil of 11748	Fine sand, 15 to 36 inches.	.3	.9	.7	60.5	28.5	5.8	3.0
11745	Subsoil of 11744	Fine sand, 12 to 36 inches.	.1	.9	2.9	37.9	33.8	16.9	7.3
11747	Subsoil of 11746	Fine sandy loam, 12 to 36 inches.	.3	1.6	3.1	38.3	30.6	17.9	8.1

MIAMI LOAM.

The soil of the Miami loam is a deep, rich, dark-brown loam, almost a silt loam, extending to an average depth of about 12 inches. Though generally of a pronounced silty character, it contains enough fine and very fine sand to render it mellow and easy to work. In some localities both the soil and subsoil contain quite a large percentage of rounded and angular stone and gravel, enough in places to hinder proper tillage. This condition is most conspicuously seen where the type joins the Volusia loam.

The subsoil is a heavier silt loam, though never as compact as in the case of the upland types, and the color is usually somewhat lighter and not infrequently mottled. In the gravelly phase of the type the gravel is more abundant in the subsoil than in the surface foot.

The Miami loam is sparingly distributed along many of the streams in different parts of the area. It occurs principally along Owasco Outlet, Dutch Hollow Brook, and Owasco Inlet, occupying flat positions only a few feet above the beds of the streams, and as a consequence the natural drainage is not very good. Drainage conditions are favored, however, by the natural porosity of the subsoil, but it is usually necessary to dig ditches through these areas to secure the best results. Many of these bottoms are overflowed as often as once a year.

The soil is alluvial in origin, being derived from the sediments brought down and deposited by the streams in times of freshet. The stony phases of the type are caused by the short, rapid, lateral streams bringing down relatively large quantities of shale and glacial gravel from the adjacent hillsides.

Much of this type of soil is available for the growing of corn, hay, and potatoes, to which crops it is well adapted, while the less well-drained portions can be profitably used for pasture. Corn produces from 40 to 50 bushels, and grass from 1 to 2 tons per acre.

The following table gives the results of mechanical analyses of the fine earth of the soil and subsoil of the Miami loam:

Mechanical analyses of Miami loam.

No.	Locality	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11750	1¼ miles NE. of Fosterville.	Dark-brown loam, 0 to 12 inches.	0.0	0.6	0.8	11.5	20.1	53.6	13.3
11754	½ mile S. of Moravia.	Brown to black loam, 0 to 12 inches.	2.7	2.7	1.3	5.2	10.7	50.9	26.0
11751	Subsoil of 11750	Dark-brown loam, 12 to 36 inches.	.1	.9	1.2	8.7	18.0	51.0	19.7
11755	Subsoil of 11754	Brown loam, 12 to 36 inches.	1.9	4.0	2.2	7.1	8.9	52.0	23.9

MUCK.[*]

The Muck, to a depth of 12 inches or more, is a black fine-grained loam, consisting of a large amount of organic matter mixed with a small amount of fine sand and silt. Where a subsoil exists it usually consists of gray clay or fine sand, or a mixture of both.

While there is a thin covering of mucky soil in many of the areas mapped as Meadow, especially in the northern part of the survey, it was only where the Muck had a depth of at least 1 foot that it was believed to have a sufficiently distinct agricultural value to warrant its recognition as a soil type. The larger areas are located in Summer Hill and Sempronius townships; smaller ones were mapped in Sennett and Throop townships.

The Muck occupies low, flat positions along streams and in swamps where there is not sufficient fall to secure drainage under natural conditions. It is formed by the decay under moist conditions of large quantities of vegetable matter constantly accumulating in these depressions. This rotting vegetation is mixed with a small amount of fine sand and silt deposited in times of high water and drifted into the swamps upon the winds.

When well drained the Muck is a very desirable soil for the production of potatoes, onions, celery, cabbage, etc. Most of the Muck mapped is in forest. A small portion has been cleared and is used for pasturage, but none is under cultivation.

MEADOW.

There is no definite character to the soil or subsoil of Meadow, it being as a rule an indiscriminate mixture of blue and yellow clay and gray sand, which is sometimes covered with a few inches of Muck. Meadow is represented in all parts of the area surveyed, but is most extensively found in the northern part, where it occupies the depressions between the glacial hills, and on the flat lands along many of the small streams. Most of this type is covered with willow, tamarack, and other water-loving trees, or with coarse, rank grasses. Much of the soil is amenable to drainage, and might be fitted for grass land at some expense. In localities where there is a covering of Muck the higher areas, when freely drained, are often well adapted to celery, onions, cabbage, and other vegetables.

AGRICULTURAL METHODS.

The agricultural methods in the Auburn area do not differ materially from those in use in many other Northern States where a fairly intensive system of farming is practiced. Deep plowing is the rule, and the land is thoroughly tilled. The land roller is a common implement on all farms, and on many it is a necessity. Great care is taken that all clods are thoroughly pulverized by the roller and harrow. This, in the case of some of the heavier soils, like the Dunkirk clay, requires the expenditure of considerable time and labor, especially when, as not infrequently happens, a late spring forces the farmer to plow for early crops while the soil is still too wet. The disk harrow is coming into very general use, except upon the farms covered with stone and flat shale, where the spring or spike tooth harrow takes its place. Sulky plows and harrows are rarely seen, though corn is worked with a riding wheeled cultivator. The old style walking plow is in general use, and the wide and deep furrow turned by it requires the use of three strong horses. The corn is cut and shocked by hand. Upon the dairy farms much of the corn is planted in drills and cut green with the corn binder, after which it is drawn to the silo and either cut or shredded by power machinery. Not all of the dairy farms, however, feed silage, owing to a difference of opinion as to the economic value of this method of feeding.

Wherever the topography and character of the surface will permit, the self-binder is used for wheat and oats, and also for barley if the straw is long enough. With the hay and large dairy farmers the piece of machinery next in importance to the mower and rake is the hay tedder, which is in very common use in the central and southern parts of the area. Nearly all of the farmers employ horse forks in unloading in the barn, and the hay loader is sometimes used in the field. Some farmers have several hundred dollars invested in machinery of this class, which, with few exceptions, is well cared for and housed from the weather when not in use.

AGRICULTURAL CONDITIONS.

In general, the farmers of the Auburn area are prospering, as evidenced by well-kept farms, substantial and attractive dwellings, and large and well-ventilated barns suited to the needs of the dairy and grain farmer. Silos and windmills are found on nearly all of the better farms. Well-ordered and closely trimmed lawns are quite often seen around the farmhouses, and special care is also given to the appearance of the highways. The weatherbeaten and unstable board fencing is fast disappearing, and in many instances the roadsides are bordered by fruit trees of various kinds, or by maple, elm, and other shade trees. In some sections of Cayuga County the fences are built of stone, while in others hedges of locust, osage orange, etc., are planted. The fence rows are for the most part kept free of briers and weeds.

The principal exceptions to these evidences of general prosperity are noted in parts of the townships of Sempronius and Summer Hill, where the fences and fields are not so well cared for and where many abandoned farmhouses are seen. This is no doubt due in part to the hindrances to cultivation offered by a very stony and less productive soil, and also to the fact that upon these farms there is more or less waste land in the form of sloping marshy meadows difficult of drainage. Owing to these natural disadvantages and the difficulties in the way of diversified farming, as well as to the extension of the dairying industry, the smaller farms are being gradually absorbed by the more thrifty and provident farmers, who have little use for the smaller dwellings except as storerooms.

From 60 to 70 per cent of the farmers of the area own their farms, about 20 per cent are share tenants, and the remainder are cash tenants and part owners. It is believed that the tenant class is gradually decreasing, a condition decidedly conducive to the increase of farm values, because of the more careful cultivation and fertilization which the farms receive from their owners than from tenants.

The farms range in size from 20 to 300 acres, the average for the county being 81 acres. Aside from the fruit and vegetable farms near Auburn, this acreage per farm is increasing, which is in part due to the demand for more land by the dairy farmers. On the other hand, as the farmers have come to realize the impossibility of competing with the West there has been a gradual decrease in the production of cereals, with a corresponding tendency toward a decrease in acreage.

For many years there has been a great scarcity of labor, and consequently wages are high. The young men have drifted to the cities to find more congenial employment, their places on the farms being supplied to some extent by laborers of an inferior class and by foreigners ignorant of American customs and methods of agriculture. This results in the farmer doing as much of his own work as possible, assisted in many instances by his wife and children. Laborers employed by the month are paid on an average about $25, with board. Much of the labor during the summer season, however, is hired by the day, a wage of from $1.50 to $2 or more being paid.

Dairying and hay and fruit growing have for a long time been the specialties of the Cayuga County farmer. Each little settlement supports a skimming station, and there are several creameries in the area. Along the line of the Lehigh and New York branch of the Lehigh Valley Railroad a great deal of milk is shipped direct to Philadelphia in refrigerated milk cars.

Timothy and timothy with clover are extensively grown and give fair yields, though the quality in some sections of the area is seriously affected by the presence of daisies and Canada thistles. A large proportion of the crop is baled and sold soon after cutting, $10 a ton being a fair average price. Barley and oats are profitable crops and yield well. The acreage of corn, except for silage, is being reduced, and this, as well as wheat, is becoming only a secondary crop. Cayuga County is one of the largest producers of buckwheat in the United States, and in point of yield per acre stands second. Vegetables are not extensively grown, except partially to supply the later home market. The culture of fruits, especially apples, pears, plums, and cherries, is an important industry. The apples are noted for their good color, fine flavor, and keeping quality, and in years of normal production give a fair profit. Grapes are grown comparatively little, except along the shore of Cayuga Lake. Peaches are grown along the lake to some extent, and the quality is excellent, but the winters are rather too severe for their profitable production. Irish potatoes yield well, and when grown upon the lighter soils, such as the Dunkirk loam, are up to the average in appearance and keeping qualities.

The adaptation of soils to crops is pretty well understood by the farmers. The heavier soils are generally selected for grass, and the most extensive areas of hay are to be seen in the townships of Sempronius and Summer Hill, where the largest bodies of the Volusia loam were mapped. The silty Volusia loam has also proved admirably adapted to buckwheat. Grape culture is almost entirely confined to the heavy Dunkirk stony clay along the eastern shore of Cayuga Lake. Apples also find their best development upon the heavier types of soil, little difference being shown in quality and yield as between the Dunkirk stony clay, Dunkirk clay loam, and Miami stony loam. The earliest market vegetables are grown upon the Miami fine sand. The extension of market gardening is advised. Excellent stands of alfalfa have been profitably grown upon the Dunkirk clay loam, and it is believed that it would do even better upon some of the lighter types of soil. It is an invaluable crop for the dairyman, and should be thoroughly tried on the Dunkirk loam. Beets for cattle feeding have given excellent satisfaction upon some of the lighter upland and bottom soils in the southern part of the county, and their cultivation might be profitably extended. In connection with dairying, poultry raising is receiving considerable attention in the central and southern parts of the area, the White Leghorn being the favorite breed.

Transportation facilities within the area are furinshed by the Auburn branch of the New York Central Railroad, which connects with the main line at Syracuse and at Rochester. The distance from Auburn to Syracuse is 26 miles, and to Rochester 77 miles. A branch of the Lehigh Valley Railroad traverses the county from north to south, making direct connections for Philadelphia, which is about twelve hours' run from Auburn. Another branch of the same road is built along the eastern shore of Cayuga Lake from Auburn to Ithaca, where connection is made with the main line. Auburn is also connected with Syracuse by electric cars, which carry express as well as passengers. During the summer months there is considerable passenger traffic by steamer on Skaneateles, Owasco, and Cayuga lakes. The last is 40 miles long, extending from Cayuga to Ithaca, and besides passengers the steamers carry a certain amount of freight.

There is only a limited home demand for the products of the area, the greater part being shipped to New York City, Boston, Philadelphia, and southward. It is a little over 300 miles from Auburn to New York City, about 325 to Boston, and about 375 to Philadelphia. The facilities for the quick handling of perishable products, and their speedy transportation to these large markets, are exceptionally good. There is without question opportunity for a considerable extension of vegetable growing for local consumption, though with the exception of such crops as celery, late cabbage, and potatoes, it is doubtful if vegetables could be profitably grown in competition with the products of the trucking sections of the Atlantic seaboard.

Auburn is a busy manufacturing city of 40,000 inhabitants, and is noted for its beautifully shaded streets and elegant homes. Fair wages are paid in most of the factories, and there is a good local demand for the best that the farm and garden afford.

SOIL SURVEY OF ADAMS COUNTY, PENNSYLVANIA.

By HENRY J. WILDER and H. L. BELDEN.

LOCATION AND BOUNDARIES OF THE AREA.

Adams County, Pa., lies along the Pennsylvania-Maryland line, about midway between the east and west boundaries of the State. It is, in general, rectangular, and thus not so irregular in outline as most of the counties in this part of Pennsylvania, and includes an area of 341,888 acres, or about 534 square miles. Gettysburg, the county seat, with a population in 1900 of 3,495, is the largest town. Other important towns are New Oxford, Littlestown, Fairfield, Cashtown, and York Springs.

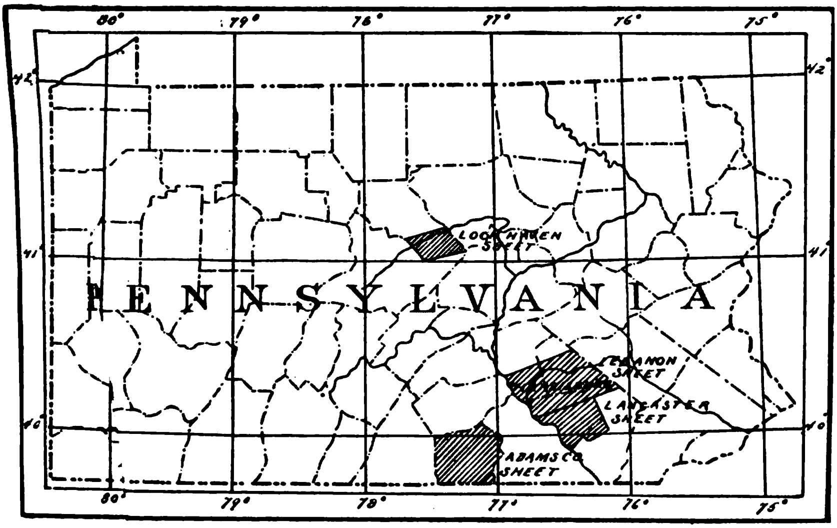

FIG. 3.—Sketch map showing location of the Adams County area, Pennsylvania.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.[a]

Contention about the boundary line between the conflicting land grants of William Penn and Lord Baltimore made each of these proprietors anxious, the better to prove his claims, to inaugurate settlements in the area now included in Adams County.

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[a] The historical facts included in this chapter are taken principally from Bates's History of Pennsylvania.

The first settlement was made in 1734 by the Germans, who were followed closely by the Scotch-Irish and the Jesuits. At that time the Delaware and Catawba Indians were at war, and while on their depredatory excursions frequently stopped at the settlements for quarters, but never inflicted any injury upon the inhabitants.

In 1739–40 the Penn estate laid out a reservation along Marsh Creek and called it the "Manor of Masque." This included all of the present township of Cumberland and the greater part of Freedom. Many Dutch settlers were coming at this time, and they settled within the limits of the "manor."

One of the early settlers of ability and resource was James Gettys, who had opened a farm, store, and country tavern at the Marsh Creek settlement. He soon conceived the idea of laying out a town on his land, deeded land to the county for various public uses, announced his intention to make this the future county seat, and offered inducements to settlers. As a result the name "Marsh Creek Settlement" was changed, in his honor, to Gettysburg, in 1780.

The clannishness and exclusiveness which had been so characteristic of the settlements of different nationalities largely disappeared with the necessity for banding together during the war of the revolution, and from that time dates the beginning of their intermingling.

The difficulty over the boundary between the Penn and Baltimore grants had been settled in 1767 by the determination of the Mason and Dixon line, with which the southern boundary of Adams County coincides.

Until the year 1800 Adams County was a part of the county of York, but the rapid settlement which took place, accompanied by the growing discontent at the distance from the county seat, led in that year, to the erection of a separate county, which was named in honor of President Adams.

For many years there were no roads except some paths through the forests used for the trains of pack horses, on which all transportation to Baltimore and other markets was carried on. The owners of these pack-horse trains violently opposed the building of roads, but in the early part of the nineteenth century several turnpike toll roads were constructed leading from Gettysburg across the county.

The Scotch-Irish settled in the northern part of the county, but they were not as successful farmers as the Germans, who had settled in the southern part, and their farms were gradually acquired by the more steady Germans as they overspread the county.

Wheat, corn, oats, barley, and buckwheat were the principal crops. Small amounts of these products were hauled to Baltimore, but for the most part they were consumed at home, while hogs, sheep, and a few cows were sent to market.

CLIMATE.

Situated on the Mason and Dixon line, Adams County has a moderate climate, and escapes the temperature extremes of both the North and the South. Crops are seldom injured either by late frosts in the spring or early frosts in the fall.

The following table, taken from the report of the Pennsylvania secretary of internal affairs, shows the mean monthly and annual temperature and precipitation at Gettysburg, in so far as the records have been kept at that station:

Mean monthly and annual temperature and precipitation.

Month.	Gettysburg.									
	Temperature.				Precipitation.					
	1839–1865.	1889.	1890.	1895.	1839–1865.	1889.	1890.	1893.	1894.	1895.
	°F.	*°F.*	*°F.*	°F.	*In.*	*In.*	*In.*	*In.*	*In.*	*In.*
January	27.8	......	39.1	......	3.14	......	2.25	2.04	1.56	......
February	30.7	......	37.8	......	2.60	......	4.51	3.46	3.89	......
March	38.9	......	......	36.2	3.00	......	4.66	2.24	1.21	1.83
April	49.9	......	48.7	49.8	3.56	......	3.31	5.20	3.94	3.27
May	60.8	......	59.6	60.9	3.85	......	3.10	7.36	6.84	3.16
June	69.8	......	70.3	71.3	3.46	......	3.91	3.26	1.78	3.10
July	73.8	......	73.3	70.0	3.40	......	2.78	1.18	1.47	1.37
August	71.3	......	70.3	74.4	3.40	3.51	3.95	3.18	2.08	2.27
September	63.4	......	......	69.2	2.98	6.81	2.51	3.29	7.60	1.24
October	50.2	49.7	......	47.9	3.03	4.16	......	4.00	......	2.13
November	40.0	40.0	......	42.8	3.05	6.47	......	2.97	......	1.55
December	31.1	39.6	......	33.4	3.43	2.01	......	1.77	......	2.37
Year	50.6	......	......	......	38.90	......	......	39.95	......	......

The above records are so broken that the following complete records of temperature and precipitation, taken in the adjoining county of York, are also given:

Normal monthly and annual temperature and precipitation.

Month.	York, Pa.		Month.	York, Pa.	
	Temperature.	Precipitation.		Temperature.	Precipitation.
	° *F.*	*Inches.*		° *F.*	*Inches.*
January	28.7	2.45	August	73.3	4.16
February	27.9	3.91	September	66.4	3.76
March	40.0	3.25	October	54.1	3.04
April	50.5	2.87	November	43.0	3.23
May	61.9	4.10	December	32.6	3.29
June	70.5	3.11	Year	52.5	40.48
July	75.6	3.31			

PHYSIOGRAPHY AND GEOLOGY.[a]

The general direction of all the principal physiographic features of Adams County is from northeast to southwest. The east-central two-thirds of the entire county consists of a broad, moderately rolling valley, which has been dissected by one continuous trap dike that enters the county from Maryland and extends entirely across it; and another similar dike, which enters the county at the same place, extends northerly beyond Fairfield and then northeasterly in a direction generally parallel to the first. The latter dike is broken several times, and so, although its course may be traced in the field, it does not appear on the map because it has not come sufficiently near to the surface to effect a change in soil type.

Flanking this broad valley on the west and north lies the South Mountain Range. The approach to this mountain is in most places abrupt, and no less so is the corresponding change of soil types. The range is broken in several places by gaps, through which the roads run, and by one important longitudinal valley, known as Buchanan Valley. At the northwest corner of the county this range spreads into a small plateau called the "Big Flat." Besides the Green Ridge, which forms the most continuous and principal part of the range, there are many steep-sided hills and small mountains, some of which are almost conical shaped, but the majority of them are long and narrow and lie parallel to the main ridge.

The main broad rolling valley of the county already mentioned is bounded on the southeast by a slightly rolling limestone valley, of which the general level is somewhat lower than the preceding. Rising from this limestone valley, and occupying the southeast corner of the county, is a moderately rolling or hilly section formerly called "The Barrens." A small area, with topography similar to that of The Barrens, occupies the extreme eastern part of the county in Berwick Township.

The drainage of the county is accomplished by two main systems. In the northwestern part, the Conewago Creek has its source, and then extends easterly to Berlin in the northeastern part of the county, draining in its course most of the northern half, and by its confluence with the Little Conewago, the southeastern part of the county. This system is terminated on the south by a low divide, which has its inception midway between Arendtsville and Hilltown, extends southeasterly to a point about a mile south of Hunterstown, and thence in a more southerly course toward Littlestown. That part of the county south and west of the divide is drained by a separate system, of which the chief branches are Rock and Marsh creeks, but these streams do not join until after leaving Adams County.

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[a] Much of the geological data contained in this report was obtained from Prof. E. S. Bridenbaugh.

Six geological divisions are represented in Adams County. Of these the most extensive is the Mesozoic (Triassic) sandstone and shale, which give rise to the soils of the Penn series. These formations, once level or but gently rolling, have been dissected by streams to greater or lesser extent, depending upon the resisting powers of the underlying rock. The valleys are usually narrow, and where their slopes are steep the underlying ledges of shale are often exposed. The principal rock of the intrusive trap dikes found in these formations is syenite, from which the soils of the Cecil series are principally derived. The intrusion of these dikes has caused varying degrees of metamorphism of the red shale and sandstone and the resulting change in color from red to blue. Sometimes the intrusive dike has failed to protrude through the surface, but approaches near to it. An example of this may be seen in the Heidlersburg road about 1 mile north by northeast of Gettysburg, just before reaching the Rock Creek bridge. Here the underlying dike comes within 6 inches of the surface, as can be seen in the small quarry where road material has been loosened by blasting. Numerous instances of this kind, varying in the distance from the surface or the degree of intrusion, occur throughout the Mesozoic formations. In the vicinity of Biglerville there are several instances where shale was deposited after the time of the intrusion of these masses as well as before.

The South Mountain Range consists of Archean rocks, chiefly gneiss. These rocks, together with the Potsdam, which is represented by considerable outcrops along the base of the South Mountain, and also in Pigeon Hills, in Berwick Township, give rise to the soils of the Porters and Dekalb series.

The limestone of the county, which is in the main blue, but contains varying amounts of impurities in the form of quartz, is Siluro-Cambrian in age, as is also the hydromica schist. Of these, the former give rise to the Hagerstown series of soils, while the latter, together with the small area of chlorite schist that occurs in the extreme southeast corner of the area, has been mapped as Cecil loam. The age to which the chlorite schist belongs has not as yet been definitely settled by geologists.

SOILS.

There are fourteen types of soil in Adams County. The actual and relative extent of each of these is shown in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Penn shale loam	100,032	29.3	Cecil loam	8,448	2.5
Penn loam	54,592	15.9	Dekalb stony loam	4,224	1.2
Porters stony loam	41,472	12.1	Meadow	3,648	1.0
Cecil clay loam	40,960	12.0	Penn sandy loam	3,392	1.0
Rough stony land	30,976	9.1	Hagerstown stony loam	1,408	.4
Porters clay	27,264	8.0	Cardiff slate loam	768	.2
Hagerstown loam	16,064	4.7	Total	341,888	
Cecil stony loam	8,640	2.5			

PENN SHALE LOAM.

The surface soil of the Penn shale loam consists of dark indian-red loam from 8 to 10 inches deep. This material is generally uniform in texture and its slight variations are due chiefly to the effects of the washings to which the type in some degree is susceptible. The subsoil consists of heavy indian-red loam, silty loam, clay loam, or loam grading into clay loam. The depth of this subsoil is most variable, as it always rests upon the shale rock from which it is derived, and the distance of this rock from the surface depends largely upon the local topography. Where level areas of considerable size occur the soil is often 3 feet deep, and at the foot of slopes it is usually deeper than that, but wherever the surface is very much broken it is seldom possible to bore below 12 to 18 inches, except in the hollows and along the bases of slopes.

From 10 to 40 per cent of shale fragments occur in the surface soil, and the quantity always increases in the subsoil until it is impossible to bore at depths ranging from 12 to 36 inches. This mass of shale fragments immediately overlies the parent shale rock to a depth of several inches, and the general statement may be safely made that the greater the quantity of shale fragments at the surface the nearer is the underlying rock. On steep slopes and bluffs along stream courses, where the soil erodes away as fast as formed, ledges and low cliffs of red shale are often exposed and their outer surfaces present the various stages of the disintegration of this rock into fragments.

The Penn shale loam includes one important variation. On each side of the long intrusive dike which, in crossing the county from northeast to southwest, passes just south of Gettysburg, the surface soil to a depth of 10 inches is a heavy blue or gray loam, which often contains a relatively high percentage of silt. The subsoil is blue or gray heavy silty loam or clay loam. Fragments of blue shale, ranging in amount from 10 to 40 per cent, occur in both soil and subsoil, and this has given it the local name of "blue gravel land," in distinction from "red gravel land," which is the local designation of the main type. Several similar occurrences of the blue gravel phase, though of lesser extent, are scattered about the county.

The Penn shale loam is the most extensive soil type of Adams County. It occurs as a broad rolling valley, which extends across the central part of the county parallel to the South Mountain Range. The prevailing gentle surface features of this valley are sharply broken by two long intrusive dikes, which give rise to soils of the Cecil series, and are rendered more steeply rolling in several sections by the intrusion of dikes of the same material which have failed to penetrate the surface, though in several instances they are but from 1 to 2 feet below it, and have consequently caused many local variations in the metamorphism of the shale.

The drainage features of the Penn shale loam depend entirely upon its topography, because the underlying beds of shale prevent the downward percolation of water to any great depth below the surface. This fact determines in great measure the crop yields and the consequent values of the soil, for its producing power depends largely upon the caprice of the seasons. In wet years considerable areas are continually wet and clammy because the excess of moisture can escape only in a lateral direction. On areas nearly level such water movement is slight, but the lower portions of slopes are kept so wet from this source in rainy seasons as to injure crops seriously, and such areas are locally termed "spouty land." The underlying shale, however, is often vertically fractured to greater or lesser extent, and thus provides for the removal of excess moisture. The type suffers even more from drought than from rainy seasons, because the shallow subsoil can retain but a small reserve supply of moisture, and when this becomes exhausted crops must succumb. In seasons when a normal amount of rainfall is evenly distributed the Penn shale loam is a safe soil and good crops are produced.

The type is derived from the beds of shale which underlie it, excepting only the lower slopes and hollows where the soil has been augmented in varying degree by the washings from higher elevations. The blue shale phase and the similar local variations above mentioned are derived from beds of shale which have been metamorphosed in varying degree, as described under "Physiography and geology."

The Penn shale loam is used for the general system of farming which obtains throughout the area, and is better adapted to this purpose than to the production of any special crop. Corn often suffers more from drought than do the cereal grains, because the latter are harvested in many seasons before dry weather has serious effect.

The relative crop value of the "red gravel land" and the "blue gravel land" is a much mooted question. The opinion is frequently advanced that one surpasses the other, but either proposition doubtless holds true only for limited sections, and then depends chiefly upon the distance of the underlying shale from the surface.

The average yield of wheat is 15 bushels; oats, 30 bushels; shelled corn, 25 bushels, and hay, 1½ tons per acre.

The results of mechanical analyses of the fine earth of both soil and subsoil are given in the following table:

Mechanical analyses of Penn shale loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
1235	3 miles E. of Gettysburg.	Red medium loam, 0 to 10 inches.	3.6	7.9	3.7	9.0	6.8	43.7	25.2
11626	2 miles N. of Hunterstown.	Brown heavy loam, 0 to 8 inches.	12.8	23.0	6.4	9.1	4.6	15.1	28.3
11624	8 miles N. of New Oxford.	Red clay loam, 0 to 8 inches.	3.1	5.1	1.2	1.8	3.7	47.9	36.8
11627	Subsoil of 11626	Red clay loam, 8 to 36 inches.	12.5	12.1	2.9	4.2	3.8	34.2	30.8
11236	Subsoil of 11235	Red heavy clay, 10 to 36 inches.	3.8	9.3	5.2	9.3	8.2	23.6	40.3
11625	Subsoil of 11624	Red clay, 8 to 30 inches...	10.7	11.2	2.7	4.1	4.4	15.4	51.5

PENN LOAM.

The surface soil of the Penn loam consists of dull-red or brown silty loam from 8 to 12 inches deep. The subsoil consists of heavy indian-red or light-brown loam, which grades into red clay loam at depths ranging from 15 to 36 or more inches. In the vicinity of New Oxford the surface soil is a fine, very mellow loam, sometimes distinctly silty in character, which becomes quite compact at a depth of from 18 to 24 inches, and the underlying red clay loam is usually from 3 to 4 feet below the surface. Sandstone fragments to the extent of from 5 to 25 per cent are a frequent feature on the surface, as well as throughout soil and subsoil, but their occurrence is not constant. When the type is derived from the soft shales, fragments of that material ranging in amount from a trace to 10 per cent may be found in both soil and subsoil.

A stony phase occurs a short distance from Conewago Creek, southwest of Biglerville. The stones are principally quartz and hardened sandstone, with occasional soft sandstone fragments, though rounded quartz pebbles, left from the decomposition of sandstone conglomerate, are found in a few localities. The Penn loam is frequently marked by knolls and ridges of Penn sandy loam. Such areas are most numerous in the eastern part of the county, but they are rarely of sufficient extent to appear on the map.

The Penn loam occurs in a large area which extends from Berlin southwest to the Maryland line, a distance of nearly 20 miles; also in a long, irregular area from Cashtown through York Springs to the county line, and in a detached area near Newchester.

The topographic features of the type are those of a broad, gently rolling valley, bounded in part by the more broken Penn shale loam and in part by the intrusive dikes of the Cecil series.

The soil is generally well drained. Small areas adjacent to streams are sometimes overflowed, and scattered minor depressions need artificial drains. In several instances tile drains have been constructed in such areas.

The Penn loam is derived from the underlying beds of Mesozoic soft sandstone and shale, but the processes of disintegration and decomposition have taken place to such degree that at present these rocks are so deeply buried beneath the surface as to have practically no effect upon the soil and its productivity.

The Penn loam is adapted to the general farm crops which are grown upon it, and as it is much less susceptible to drought than the Penn shale loam it far surpasses the average of that type in the production of corn and is somewhat superior for the small grains and hay.

Corn yields an average crop of 35 bushels, wheat 18 bushels, oats 35 bushels, and hay 1½ tons per acre.

The following table shows the results of mechanical analyses of the fine earth of soil and subsoil of this type:

Mechanical analyses of Penn loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11616	1¼ miles NW. of Center Mills.	Red silty loam, 0 to 10 inches.	4.2	7.2	8.1	8.3	12.0	48.4	16.8
11618	1 mile N. of York Springs.	Red silty clay loam, 0 to 10 inches.	2.3	3.2	.8	1.5	6.6	58.2	27.1
11617	Subsoil of 11616	Loam to clay loam, 10 to 36 inches.	3.5	8.1	2.4	5.3	10.6	46.4	23.7
11619	Subsoil of 11618	Loam to clay loam, 10 to 36 inches.	2.8	4.7	1.2	1.9	7.2	53.8	27.9

PENN SANDY LOAM.

The surface soil of the Penn sandy loam consists of light, medium, or heavy sandy loam, which ranges from coarse to fine in texture, from 6 to 15 inches deep. Its color is brown, indian red, or, rarely, yellow. From 10 to 30 per cent of sandstone fragments are not uncommon, but these are not a constant feature. The subsoil consists of a variety of materials, but is usually a loam or silt loam. Frequently, however, the underlying sandstone is reached by the auger, and in this case, or where the sandstone bed rock is but 4 feet or so below the surface, the subsoil is often a sandy loam, which grades into sand as the rock is approached. In such case, which most often occurs on sharp slopes or on the crest of narrow ridges, the amount of sandstone fragments increases with depth, and for several inches above the parent rock a mixture of rock fragments and sand is found.

The principal area of the Penn sandy loam extends from near Littlestown southwest to the Pennsylvania-Maryland line. There its surface features are much varied, and it occupies hills, gentle slopes, and valleys alike. There is no regularity in its occurrence save in the area just mentioned. It is generally associated with the Penn loam, where it is found in many detached areas in every physiographic position of a moderately rolling country.

The Penn sandy loam is well drained, and crops sometimes suffer from lack of moisture late in the summer, but this seldom happens before the wheat and hay have been harvested.

The type is derived from Mesozoic sandstones and sandy shales.

The general farm crops of the area are grown upon this soil. Corn yields from 25 to 65 bushels of shelled grain, wheat from 12 to 25 bushels, oats 30 to 55 bushels, rye 15 to 30 bushels, and hay from 1 to 2 tons per acre. The type is well adapted to potatoes and early garden produce.

The following table shows the results of mechanical analyses of the fine earth of soil and subsoil of the Penn sandy loam:

Mechanical analyses of Penn sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11612	1½ miles NW. of Littlestown.	Medium sandy loam, 0 to 8 inches.	3.1	14.4	11.2	31.5	8.7	14.7	16.3
11614	3 miles SW. of Littlestown.	Brown sandy loam, 0 to 10 inches.	1.5	9.2	9.1	22.7	12.5	27.8	17.4
11615	Subsoil of 11614	Brown medium loam, 10 to 36 inches.	2.9	7.1	6.1	18.0	13.6	32.5	19.8
11613	Subsoil of 11612	Sandy loam to sand, 8 to 36 inches.	2.2	7.8	9.7	35.4	10.7	14.3	19.5

CECIL CLAY LOAM.

The surface soil of the Cecil clay loam to an average depth of 10 inches consists of reddish-yellow or light-brown clay loam. The subsoil consists of reddish-yellow or light-brown clay loam grading into a clay in its lower depths. The subsoil often contains a considerable amount of particles of the disintegrated rock from which the type is derived. This character of material may extend to a depth of 36 inches or more, but frequently the clay content decreases below 30 inches, and the amount of disintegrated rock particles increases until the underlying mass of stones and rocks is reached. From 10 to 30 per cent of stones and bowlders, principally syenite, are commonly present in both soil and subsoil, and spots are not infrequent which are very stony; but, in general, the amount of stones is not sufficient to interfere seriously with cultivation.

The Cecil clay loam as mapped presents a variation which, though usually small in extent, occurs in numerous instances. In nearly all parts of the county where this type has been mapped it includes areas of clay underlain by a stiff heavy clay. Such areas would have been mapped as Cecil clay had their extent warranted it. There is no regularity in the occurrence of these areas, and they are likely to be found in any topographic position which the entire type includes.

Local areas of this soil are often incorrectly classed by farmers as sandy loam in distinction from the heavier phases of the type. This is due probably to the presence of small amounts of coarse, sharp sand—disintegrated particles of syenite—which in places gives to the soil a gritty feel. The presence of such particles is misleading, as they are insufficient in amount even to constitute a light phase of the type. From 10 to 30 per cent of stones are found on small areas of this type, and also occasional bowlders.

The Cecil clay loam occurs in long strips, which extend entirely or partially across the central part of the county from northeast to southwest. This position and the topographic features of the type depend directly upon the nature of the geological formation from which the soil is derived. This formation has already been described under "Physiography and geology." The surface features of the type range from moderately to steeply rolling, with but small areas of level land. It usually occupies entire dikes or the lower slopes of dikes of which the upper and steeper slopes and the summits are occupied by the Cecil stony loam, or Rough stony land.

Surface drainage is rapid with such topographic features, and small gullies are sometimes formed. Soil transportation steadily takes place, where gullies are not formed to an appreciable extent, and consequently the soil, as a rule, is much deeper on the lower and more gentle slopes than on the upper slopes and the summits of the hills and ridges. The heavy character of the subsoil makes it retentive of moisture, and this enables the type to withstand drought much more successfully than soils of the Penn series.

The Cecil clay loam has been derived chiefly from syenite, which is the principal rock of which the intrusive dikes are composed, but in some localities other metamorphic rocks have played some part in its formation.

The greater part of the Cecil clay loam is cleared and cultivated, but the roughest sections are used as permanent pasture, or left in forest, which includes all the common hardwood varieties.

The Cecil clay loam is a good corn soil, and is much safer for that crop than the Penn shale loam, because it is much less susceptible to drought, though in favorable seasons there is little difference in yields. Good crops of wheat, oats, rye, and hay are also grown.

The average crop yields are estimated as follows: Corn, 30 bushels; wheat, 15 bushels; oats, 30 bushels, and hay, 1½ tons per acre.

The results of mechanical analyses of the fine earth of both soil and subsoil are given in the following table:

Mechanical analyses of Cecil clay loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11582	2 miles S. of Mummasburg.	Brown clay loam, 0 to 8 inches.	1.4	4.2	2.0	4.7	5.1	49.7	32.8
11580	3 miles SW. of Heidlersburg.	Brown clay loam, 0 to 10 inches.	2.2	4.1	1.4	3.0	4.7	48.7	35.4
11583	Subsoil of 11582	Clay loam to clay, 8 to 36 inches.	4.1	11.5	4.0	9.2	5.4	33.6	32.1
11581	Subsoil of 11580	Clay, 10 to 36 inches	1.8	2.2	.8	1.8	2.6	41.2	50.2

CECIL STONY LOAM.

The surface soil of the Cecil stony loam to an average depth of 10 inches consists of heavy red loam or clay loam. The subsoil consists of light-red clay loam or clay, which usually grades heavier in texture with increasing distance from the surface, but in places it begins to grow lighter at a depth of 30 inches, and grades gradually into a mass of disintegrated syenitic rock. Both soil and subsoil contain from 30 to 60 per cent of stones and bowlders. Where not too numerous, the bowlders, which are mostly syenite and range from 1 to 3 feet in diameter, have been removed and utilized in the construction of fences about the fields. The small stones are largely "ironstones," and many large heaps of these are seen along the fields from which they have been picked.

The Cecil stony loam occurs in small areas on the intrusive dikes which have cut across the county.

The topographic features of the Cecil stony loam are always more or less broken and hilly. The type often occupies the steep slopes at lower elevations than the Rough stony land, and includes entire hills and ridges where that type is lacking or too small to appear on the map.

Surface drainage is so rapid, on account of the physiographic features of the type, that washing often takes place on the cultivated fields. The subsoil is so retentive of moisture, however, that the type seldom suffers from drought. The Cecil stony loam is derived from syenite, and also in slight degree from the other metamorphic rocks of the intrusive dikes. A large part of the type is covered with forest growth, which consists largely of oak, with lesser amounts of chestnut and locust.

The least stony parts of the Cecil stony loam are adapted to the general farm crops of the area that are grown upon them, but the fields are so small and irregular that it is hardly possible to give accurate estimates of crop yields, and the same feature lessens, in varying degree, the desirability of using the soil for cultivated crops. The least stony areas are well suited to the growing of apples, and where well drained offer good opportunities for the profitable development of this industry. The areas unsuited to the above uses can best serve as pasture or woodland.

The following table shows the results of mechanical analyses of the fine earth of soil and subsoil of this type:

Mechanical analyses of Cecil stony loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11578	3 miles NE. of Fairfield.	Brown heavy loam, 0 to 7 inches.	4.7	16.4	4.7	10.3	9.5	29.1	25.1
11579	Subsoil of 11578	Loam to clay loam, 7 to 36 inches.	5.9	21.5	6.6	11.5	9.8	20.1	24.6

HAGERSTOWN LOAM.

The surface soil of the Hagerstown loam consists of mellow loam or silty loam, from 8 to 12 inches deep, ranging in color from brown to dark yellow. The immediate subsoil consists of silty loam, slightly heavier and more compact than the soil. Its color is deep yellow, often marked with a tinge of red which gradually becomes more pronounced until, in the lower subsoil, it is deep red. This change in color takes place generally from 2 to 4 feet beneath the surface, and coincident with it the subsoil grades into a stiff clay. The type is remarkably uniform in texture, the chief variation occurring along the foot of the slopes, where the mellow loam has accumulated and the stiffer red clay loam thus lies at a greater depth. The type is free from stones with the exception of fragments of chert. These may be absent, but usually they are found to the extent of from 5 to 25 per cent in both soil and subsoil, being greatest in amount on the low hills and ridges, where the subsoil generally contains a greater proportion than the soil, although the proportion is sometimes reversed. These fragments range in size from mere particles to 3 or 4 inches in diameter, but the greater part of them are from 1 to 2 inches. A local variation of the type occurs about 1 mile east from Fairfield, where a heavy clay loam soil is underlain by heavy plastic clay. If of sufficient extent, this would have been mapped as Hagerstown clay.

The Hagerstown loam is found in two parts of the county widely separated. The most important area is in the southeastern part, where it extends from Littlestown northeasterly to the county line, including most of the Conewago Valley. Another considerable area which occurs at Fairfield extends both north and south from that point, growing gradually narrower until terminated by the surrounding hills. Scattered areas are also found in the vicinity of Cashtown, where they are associated with the larger bodies of Hagerstown stony loam.

The Hagerstown loam, although it occupies shallow valleys and is less hilly than most of the surrounding soil types, does not include large level areas, but, as a rule, is moderately rolling. The most hilly parts occur along its boundaries with other types.

Such physiographic features make for this soil drainage conditions generally adequate, but some of the lowest-lying portions of the type have been much improved by tile drains.

The Hagerstown loam is derived from the massive blue limestone formation of Cambrian-Silurian times. The bed rock sometimes protrudes through the surface, but usually it is covered with soil from 3 to 20 or more feet deep. The limestone contains considerable impurity in the form of veins of quartz, which give rise to the principal parts of the fragments found in this soil. The limestone is quarried and burned at numerous places where it comes near enough to the surface for economical working. The burned lime is applied to the land, and is extensively used for this purpose in the immediate locality of its production, as an occasional heavy application of it, especially in connection with barnyard manure, is considered very profitable.

The Hagerstown loam is an excellent soil for the production of all general farm crops. The most rolling parts are well adapted also to apple growing, but the soil is held in such high esteem for general farming that orchards are seldom planted upon it.

The principal crops grown and the average yield of each are: Wheat, 21 bushels; shelled corn, 50 bushels; oats, 30 bushels, and hay, 1½ tons per acre, though much higher yields are obtained in favorable seasons.

The following table shows the results of mechanical analyses of the fine earth of both soil and subsoil of this type:

Mechanical analyses of Hagerstown loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11598	2 miles NE. of Littlestown.	Brown clay loam, 0 to 10 inches.	2.2	3.0	1.3	2.3	5.1	52.2	33.8
11600	½ mile NE. of Littlestown.	Brown clay loam, 0 to 12 inches.	4.2	4.6	1.5	3.4	5.6	37.9	42.7
11601	Subsoil of 11600	Silty clay, 12 to 36 inches.	5.8	5.9	1.7	3.8	4.0	35.0	43.7
11599	Subsoil of 11598	Yellow clay, 10 to 36 inches.	.8	1.1	.4	1.5	7.6	35.3	53.2

HAGERSTOWN STONY LOAM.

The surface soil of the Hagerstown stony loam consists of medium brown loam 8 inches deep. Occasionally the content of fine sand is sufficient to give the soil the character of a fine loam, but such areas are of small extent. The subsoil consists of heavy yellow loam, which grades into clay loam at an average depth of 30 inches. The amount of stones present in both soil and subsoil varies greatly. From 25 to 40 per cent of chert, quartzite, and hardened sandstone are commonly found, and the amount is greater than this on local patches. The Hagerstown stony loam occupies but a few small areas in Adams County, the largest and most important of which is at Cashtown. A few scattered areas also occur near Fairfield. The type is moderately rolling and is generally well drained.

The Hagerstown stony loam is derived from a cherty form of limestone, and the principal part of the stone content of the soil consists of fragments of chert which were originally embedded in the parent limestone rock.

On lower slopes the texture of the soil has been affected slightly by material washed from other soil formations which occur at higher elevations, and the character of the stones on the surface near such boundaries varies somewhat.

The Hagerstown stony loam, where the topography is such as to secure good drainage, is best adapted to the production of apples and peaches. Where not too stony, the type is also well adapted to general farm crops, producing yields only a little below those obtained on the Hagerstown loam.

The following table shows the results of mechanical analyses of the fine earth of both soil and subsoil of this type:

Mechanical analyses of Hagerstown stony loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11596	¼ mile NE. of Cashtown.	Brown loam, 0 to 8 inches.	3.4	6.4	2.9	4.6	7.5	50.5	24.7
11597	Subsoil of 11596	Heavy yellow loam to clay loam, 8 to 36 inches.	4.1	7.2	3.0	5.0	6.0	45.8	28.7

CECIL LOAM.

The surface soil of the Cecil loam to an average depth of 8 inches consists of medium light-brown loam, often containing a relatively high percentage of silt. This material is always mellow, and when not well moistened by rain it becomes light and fluffy. The subsoil consists of heavier loam than the soil, and with increasing depth the color grades from light brown to pale red or yellow. The subsoil contains varying amounts of mica particles, but always enough to give it the greasy feel characteristic of soils derived from rocks which carry a high percentage of mica. Finely divided mica scales are usually found in the surface soil also, but in much smaller quantities. Small areas of the type are free from stones, but generally rock fragments, ranging in diameter from 1 to 6 inches, are present. With the exception of a few isolated patches, however, these fragments are insufficient in amount seriously to interfere with tillage. They are greatest in quantity on the steepest of the hills and knobs, where the average amount is about 40 per cent. In such positions the soils show a slight tendency to wash, and the finer particles have been accumulated to some extent in the little hollows, giving to the soils there the texture of heavy loams, while the resulting soils on the elevations are correspondingly coarser in texture and approach in a few minor instances heavy sandy loams. On the surface of the low-lying places the amount of stones is seldom as much as 10 per cent, but the subsoil often is as stony as on the hills. Throughout the formation the content of rock fragments increases below a depth of from 1 to 2 feet, and occasionally a mass of partially decomposed schist and loose stones is found at 30 inches or below.

The chief part of the area occupied by Cecil loam is moderately rolling to hilly. Gentle slopes of considerable extent are common, but there are also numerous low, steep hills and knolls which give the type a much varied aspect.

The many minor streams resulting from the irregular surface features of this formation secure for it ample drainage, except in a few small hollows shut in by surrounding hills.

The Cecil loam is derived chiefly from mica schist and chlorite schist rocks. The latter predominate in the extreme southeast corner of the area, and are bordered on the north by a preponderance of the former, but they are much intermixed, and the soil resulting from their decay is very uniform. Other scattering crystalline rocks have had but minor influence on the formation of this soil.

The occurrence of the Cardiff slate loam, with its underlying slate quarries, along the border of this type probably explains why the entire Cecil loam formation with its fragments of mica schist is often spoken of locally as a slaty soil.

About three-fourths of the type is tilled, the most stony and hilly parts being left in forest. The trees are largely chestnut, and for this reason the type is often designated " chestnut land."

When the area occupied by the Cecil loam was first settled—about the year 1739—the ground was almost destitute of large timber, and for this reason it received the name " Barrens," which name it has since retained. This treeless condition was caused, it is said, by the burning of the undergrowth every few years by the Indians. After white settlers came the conflagrations ceased, and in the course of time the tract became well timbered with chestnut, oak, and hickory. The section was but sparsely settled, however, for a long time. It was generally considered unproductive, and with the exception of small areas around the scattered buildings it was uncleared. The development of this section has taken place mostly within the last decade, and crops during the present season, which compare favorably with those of the limestone valley, make it seem strange that this section should have remained unpopular for so long. The soil is warm and can be worked earlier in the spring than the heavier soils.

At the present time the farms are generally well kept and tidy. Good crops of corn, wheat, rye, and hay are obtained, and in the wet seasons the yields are not below those of the more popular soils. Oats, on account of rust, are no longer grown to any extent.

Many small peach orchards are found on the Cecil loam, and it would seem that their culture might well be extended. The soil can be bought, with improvements, at an average price of $40 an acre, and, considering the much higher prices of the surrounding soils, offers to intelligent farmers good opportunities either for special or general farming.

The following table shows the results of mechanical analyses of the fine earth of soil and subsoil of this type:

Mechanical analyses of Cecil loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11588	2 miles S. of Littlestown.	Heavy silty loam, 0 to 9 inches.	1.4	3.5	3.7	2.4	4.2	55.7	28.9
11590	4 miles SE. of Littlestown.	Heavy clay loam, 0 to 8 inches.	4.5	4.1	1.7	4.0	5.8	39.8	39.7
11589	Subsoil of 11588	Clay loam, 9 to 36 inches.	4.0	6.6	2.1	4.9	4.8	47.8	29.6
11591	Subsoil of 11590	Heavy clay loam, 8 to 36 inches.	8.8	5.5	3.2	6.8	5.2	33.1	37.6

CARDIFF SLATE LOAM.

The surface soil of the Cardiff slate loam, to a depth of from 8 to 12 inches, consists of heavy fine loam to clay loam, which varies in color from blue to gray. Slate fragments from 4 to 8 inches long are not uncommon, and the surface soil contains from 10 to 40 per cent of slate particles and small fragments. The subsoil consists of a silty clay loam, grading into light clay, but usually the small fragments of slate are so numerous that it is impossible to bore below 15 or 20 inches, and at a depth of 3 feet or more this mass of broken slate rests upon bed rock. This rock, for the most part, is steeply inclined, and thus its cleavage prevents the too rapid drainage which would follow if its flat surface were uppermost.

The Cardiff slate loam occupies a long, narrow ridge in the Conewago Valley, where it leads toward the Pigeon Hills, and also a border area between that valley and the Cecil loam formation south of it. In the former position it represents an intrusive dike, and in the latter it is derived from similar slate rock, which outcrops along the northern border of the Cecil loam beneath the more metamorphosed mica schist of that formation.

Fair yields of corn, wheat, oats, and rye are obtained from this soil. Its position is such that not all of it is tilled. Peaches and apples do well and the more stony places might profitably be devoted to these crops.

The following table shows the results of mechanical analyses of the fine earth of soil and subsoil of this type:

Mechanical analyses of Cardiff slate loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11576	2 miles SE. of McSherrystown.	Clay loam, 0 to 10 inches..	2.3	1.6	0.5	2.0	15.3	42.8	35.5
11577	Subsoil of 11576	Clay, 10 to 36 inches	2.1	1.5	.6	2.8	8.9	39.0	45.6

PORTERS CLAY.

The surface soil of Porters clay consists of heavy loam or clay loam, brown or dark gray in color, from 6 to 15 inches deep. The subsoil consists of pale-red or light-brown clay loam or clay. From 15 to 25 per cent of stones and angular rock fragments are usually present in both soil and subsoil, but they are never of sufficient size materially to impede cultivation. The distribution of the stones is very irregular. Usually they are most numerous on low hilltops and steep slopes, while there are few or none on gentle slopes; but in other cases their amount seems to bear no relation whatever to topography.

The Porters clay is found in Adams County in the South Mountain Range and along its lower slopes to the east and south, and also in the Pigeon Hills in Berwick Township. The largest area lies in the extreme northern part of the county, where the South Mountain Range passes into Cumberland County. Here its topographic features are moderately rolling, and although level areas of more than a few acres in extent are seldom seen, yet little of the type is so steep as to be troublesome in working or to impair very much its agricultural value. In the mountains this soil is found in the valleys and coves. Where these are broad and the slopes to the surrounding mountains are only moderately rolling for some distance the type occurs in considerable areas; but where they are narrow it is found only in small areas or is displaced altogether by the Porters stony loam.

The surface drainage secured by the physiographic features just described is ample for most of the type. Small, and consequently unimportant, level areas adjacent to the streams which drain the main valleys in the mountains are so wet as to be swampy; and, on the other hand, small gullies are sometimes formed on the steepest slopes by surface washing.

The Porters clay is derived from the rocks of Archean age, of which the South Mountains are composed—chiefly gneiss, orthofelsite, and quartzite. Along the east and south slopes of the South Mountain range, and just along the line of contact between the Archean rocks of that formation and the Mesozoic rocks which lie below it, are the most important areas of the Porters clay. Certain parts of these areas, seldom large, are derived principally from the rock locally known as "copperstone." These areas, popularly termed "copperstone land," are more productive than the general type, and are considered nearly equal in fertility to the limestone soils.

The Porters clay of the mountain areas is fairly well adapted to general farm crops, and where the type is sufficiently rolling to have adequate drainage it is well adapted to the production of apples and peaches. The copperstone phase and the adjoining part of the type along the lower mountain slopes are excellent soils for general farming and are also well adapted to fruit production.

The average crop yields of the entire area of Porters clay would be so misrepresentative of the different sections as to be valueless, and so are not given. This apparent discrepancy in the crop yields is due much less, however, to the natural productivity of the soil than to its management. Methods are far less intensive within the mountains than along the foot of them from Cashtown to York Springs, and thence to the northern extremity of the county, and crops yield accordingly. In the mountains the average yield of wheat is 14 bushels per acre, when it is not injured by the Hessian fly; rye, 12 bushels, and corn, 25 bushels. Grass generally grows short and thick, and the average yield of hay is three-fourths ton per acre. The lower portions along stream courses seem too cold for the production of good yields of hay. On the "copperstone" and adjoining areas the average yield of shelled corn is 40 bushels, wheat, 18 bushels, and hay, 1 ton per acre.

The following table shows the results of mechanical analyses of the fine earth of the soil and subsoil of this type:

Mechanical analyses of Porters clay.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11562	Buchanan Valley....	Brown clay loam, 0 to 10 inches.	5.2	7.3	3.0	4.7	3.2	47.1	29.5
11564	4 miles N. of Cashtown.	Brown heavy clay loam, 0 to 10 inches.	2.0	5.0	3.2	8.8	8.4	32.4	40.3
11563	Subsoil of 11562......	Yellow clay loam, 10 to 36 inches.	4.2	6.5	2.6	4.8	3.2	48.0	30.7
11565	Subsoil of 11564......	Yellow clay, 10 to 36 inches.	3.2	5.2	2.7	7.7	7.2	32.6	41.4

PORTERS STONY LOAM.

The surface soil of the Porters stony loam consists of light to heavy brown loam or occasionally clay loam, from 8 to 12 inches deep. The immediate subsoil is heavy loam, but with increasing depth this material grades into a clay loam which usually extends to a depth of 36 inches, though in places it is replaced by light-red clay at a depth of 30 inches. The stone content varies widely. The most level portions contain from 20 to 50 per cent of gneiss fragments, quartz conglomerate, etc., with but few large stones. The gneiss fragments are mostly small, and because of their presence this soil is usually termed "Mountain gravel land." The ridges and steep slopes are more stony than the areas just described, and the latter often lead to Rough stony land on higher slopes or the tops of hills and ridges. Numerous patches of Rock outcrop or Rough stony land are often found scattered about the steepest parts of the type. Along Green Ridge such areas occur as a strip along the crest, outcropping here and there in irregular series.

A lighter phase of this type occurs in several instances on hills and ridges, scattered about the true type. The soil consists of medium sandy loam to a depth of 8 inches, and contains from 30 to 70 per cent of stones. These stones are chiefly flaggy sandstones, with lesser amounts of quartzite. The principal part of the stones and bowlders which were formerly on the most level areas of this soil has been removed, and the content of small stones does not make tillage difficult. The subsoil is a heavy sandy loam, or loam underlain by clay loam at depths ranging probably from 24 to 36 inches, though it is seldom possible to bore to this depth on account of the high content of rock fragments. Areas of this nature would be mapped as Dekalb stony loam if their extent and manner of occurrence were such as to make this classification possible.

The Porters stony loam is found in the western and northwestern parts of the county, where it occurs either among the hills and ridges of the South Mountain Range or on some of the outliers of that range.

The topographic features of the type are much diversified. In general, its moderately or steeply rolling surface is much broken by many steep-sided hills and ridges, the tops and upper slopes of which have been mapped usually as Rough stony land.

Good surface drainage is provided for this type by its physiographic position, and in the steeper places the drainage is often excessive; slight washing results and crops are unable to withstand periods of drought.

The Porters stony loam is derived principally from the gneiss, orthofelsite, and quartz conglomerate rocks included in the South Mountain Range. The material resulting from this rock decay is largely in place on the more level positions, but on steep slopes the surface soil has been modified in varying degrees by the agencies of soil transportation.

The Porters stony loam seems eminently adapted to the production of apples and peaches, and several orchards have already been started. The trees thrive and fruit of excellent quality is produced. Freight rates to the nearest cities are so high, however, as seriously to interfere with the production of peaches on a large scale, and the steady spread of the San Jose scale will soon ruin the apple industry unless effective measures are used to combat this pest.

Fair yields of the general farm crops are obtained. Corn brings an average yield of 20 bushels, wheat 12 bushels, rye 12 bushels, and hay three-fourths of a ton per acre. The most stony and steepest places are often used as permanent pasture.

Small areas of very stony "copperstone land" have been included in this type. The soil texture of such areas exhibits no marked variation from the main part of the type. This phase is somewhat more productive than the rest of the type, but the better methods of cultivation which obtain upon it on account of its location have much to do with the greater yields.

The mechanical analyses of the fine earth of both soil and subsoil of the Porters stony loam are shown in the following table:

Mechanical analyses of Porters stony loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11570	3 miles W. of Cashtown.	Brown medium loam, 0 to 8 inches.	7.3	9.7	3.7	6.9	5.9	47.1	19.4
11572	2 miles W. of Cashtown.	Brown clay loam, 0 to 8 inches.	7.1	8.3	2.8	4.4	5.0	39.6	32.8
11571	Subsoil of 11570	Heavy yellow loam, 8 to 36 inches.	9.2	4.1	3.8	6.6	9.9	43.2	22.6
11573	Subsoil of 11572	Light clay loam to clay, 8 to 36 inches.	6.4	7.6	2.4	4.5	4.7	36.3	38.1

DEKALB STONY LOAM.

The surface soil of the Dekalb stony loam consists of brown, yellow, or gray medium sandy loam from 6 to 10 inches deep. The subsoil ranges from heavy yellow sandy loam to light-red clay loam, resting upon a mass of sandstone and quartzite fragments. The depth of the subsoil varies greatly. On the level portions of the area at the extreme northwest corner of the county it is often 36 inches or more deep, but in other places, and especially where the topography is more hilly, it seldom exceeds 24 inches, and is often much more shallow. From 25 to 50 per cent of rock fragments are scattered over the surface and mingled with the soil and the upper subsoil. These fragments are mostly flat, flaggy sandstones varying in diameter from 1 to 10 inches. There are few large stones, and these are usually found only on the steepest positions, where erosion has been rapid and the soil has been washed away in varying degree, leaving the underlying mass of rock fragments either exposed or near the surface. Depending largely upon the steepness of position and the extent to which consequent erosion has taken place, thereby augmenting the stone content of the soil, the Dekalb stony loam generally grades into or is bounded abruptly by the area mapped as Rough stony land. The most important area of the Dekalb stony loam is found in the extreme northwest corner of the county, where it occupies a small table-land and part of the escarpment leading to it with some steeply rolling land adjoining. Another area lies along the mountain streams—Conococheague Creek and Birch Run—occupying the valleys of these streams and the foothills and lower mountain slopes on each side. A third area is found on Pine Hill, and several scattering areas occur in the Pigeon Hills of Berwick Township.

The drainage of the Dekalb stony loam is always sufficient, except on small level areas adjacent to Conococheague Creek, which are subject to overflow in times of freshet. The open texture of much of the type and the underlying masses of rock fragments render the soil unretentive of moisture, and crops can not withstand any considerable period of drought, but on the area known as "the flats" the clay loam subsoil is deeper than elsewhere and crops do not suffer in seasons of normal rainfall.

The Dekalb stony loam is derived from quartzite, quartzose sandstone, and conglomerate, Potsdam and Azoic in age. The quartz particles in these rocks are very firmly cemented together, and consequently they break up slowly.

On the area of the Dekalb stony loam known as "the flats" fair yields of rye, oats, wheat, and corn may be produced, if the soil is carefully managed, but it will be difficult to meet the competition of better soils. Several peach orchards have been started on this area, and where the land is in such condition that the cost of starting an orchard is not too great this industry undoubtedly offers opportunities for profitable development. Potatoes might be grown profitably on the more level fields which are not too stony. The greater part of the type is left in forest, and, with the exception of the most level places, which are underlain by a heavy subsoil and are not so stony as to be troublesome in working, this is the best use to which it can be put. As managed at present, the crops are planted mostly in young peach orchards or else in scattered areas, and in either case the yields are low.

The following table shows the results of mechanical analyses of the fine earth of samples of both soil and subsoil of this type:

Mechanical analyses of Dekalb stony loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11592	Near NW. corner of Adams County.	Brown sandy loam, 0 to 8 inches.	5.2	22.4	12.2	23.9	5.9	19.0	11.2
11594	1 mile W. of Mountain Creek.	Light sandy loam, 0 to 6 inches.	7.3	15.7	12.8	20.8	5.0	18.4	19.9
11595	Subsoil of 11594	Heavy sandy loam, 6 to 36 inches.	5.8	22.8	14.6	22.4	5.5	15.6	13.3
11593	Subsoil of 11592	Yellow sandy clay, 8 to 36 inches.	10.2	15.8	11.5	17.4	4.1	11.9	28.7

ROUGH STONY LAND.

Areas which in the main are too rough and stony to be included in either of the types of stony loam have been indicated on the map by symbol. Such areas often contain spots here and there of mere rock outcrop, but the type as a whole is not sufficiently stony to be so classified.

Large areas of Rough stony land are found in the South Mountain Range, and small areas occur along the intrusive dikes which traverse the county. In the former position such areas are associated usually with the Porters stony loam and in the latter position with the Cecil stony loam.

The principal part of the Rough stony land is left in forest. The original timber growth has been cut from most of it, and a scrubby second growth has sprung up. Forest fires have spread over large tracts, and the appearance of such areas is desolate in the extreme. The State government has acquired a great quantity of this land along the western side of the county at a uniform price of $3.50 an acre. Such areas will be kept as a forest preserve, and forest warders are now stationed there to care for the property. That the State has taken up the matter is most fortunate, for otherwise there would be little opportunity for the growth of timber in the face of extensive forest fires, such as were common when no one was responsible, and of the ruthless destruction by chance tree cutters.

Small areas of the Rough stony land which adjoin farms in various parts of the county are utilized to some extent for pasturage, and the best parts of the type when conveniently located near better land may be used to advantage for this purpose. On South Mountain small houses are sometimes seen on cleared patches of this type, ranging in size from one-half of an acre to 3 or 4 acres, and some attempt is made toward tillage, but this represents a condition of circumstances rather than soil adaptation.

MEADOW.

The surface soil of Meadow, to an average depth of 9 inches, consists of heavy gray, drab, or light-brown clay or clay loam. The soil is fine and free from grit, and in places the silt is quite noticeable. The subsoil, to a depth of 36 inches, is a gray, mottled-yellow, or drab clay, and below 3 feet the clay content generally increases and the soil becomes more plastic.

Meadow occurs in the Conewago Valley and in Carroll's tract as low-lying land adjacent to stream courses and the lower slopes adjoining. From its topographic position much of the type may appear as valley land, yet its boundaries with the adjoining Hagerstown loam, which is elevated slightly above it, are not often sharply marked, and its physiographic features for the most part may be said to be included in a very shallow trough. It also occupies depressions in the uplands about the head of streams, as well as low-lying, narrow areas along stream courses.

On this type of soil the drainage is generally deficient. Surface drainage on the slopes back from the streams is adequate, but near the streams overflows are more or less frequent, and in very wet seasons considerable damage is done to crops. Tile drains in some places would afford adequate drainage.

This soil is derived in part from the decomposition of the underlying limestone, and also from the fine material washed from the adjoining types of soil.

With proper drainage the Meadow is well adapted to hay and wheat, and in a less degree to corn. Where cultivated, the average crop yields are as follows: Corn, 35 bushels; wheat, 15 bushels, and hay, 1½ tons per acre. A considerable proportion of the type is used for pasturage and is best adapted to this purpose.

The following table shows the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Meadow.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P ct	*P ct*	*P ct.*	*P ct.*	*P.ct.*	*P ct.*	*P.ct.*
11608	1 mile N. of Arendtsville.	Light clay loam, 0 to 6 inches.	0.5	1.2	0.7	1.7	2.9	59.9	33.0
11610	3 miles N. of Hunterstown.	Brown clay loam, 0 to 8 inches.	.4	2.0	1.2	3.3	4.0	52.9	36.2
11604	3 miles NE. of Littlestown.	Heavy clay, 0 to 9 inches..	.8	1.8	1.1	3.4	4.0	30.7	58.0
11606	1¼ miles W. of McSherrystown.	Heavy clay, 0 to 10 inches.	.2	2.6	1.7	4.0	2.5	30.4	58.6
11611	Subsoil of 11610......	Heavy clay loam, 8 to 36 inches.	2.6	4.1	.9	2.5	5.1	53.9	31.5
11609	Subsoil of 11608......	Gray clay, 6 to 36 inches..	1.4	3.1	1.5	3.6	3.4	44.2	42.5
11605	Subsoil of 11604......	Gray clay, 9 to 36 inches..	1.4	2.4	1.4	3.4	3.0	41.5	47.3
11607	Subsoil of 11606......	Clay, 10 to 36 inches......	Tr	1.4	8	3.0	4.0	42.6	48.3

AGRICULTURAL METHODS.

The agricultural methods in use in Adams County are, in general, very well adapted to the extensive system of farming which prevails, but there is little evidence of the adoption of more intensive methods to meet the changed conditions and the more active competition of the last few years. The rapid increase in the number of farms rented during the last fifteen years is in larger measure responsible for this, for the inclination is strong, as is but natural, for the owners to expect the same methods of management to be followed by tenants which they themselves have pursued with success in years gone by; and there is thus little opportunity for tenants, if, indeed, there is much inclination, to undertake any innovation in farming methods.

The methods of cultivation are fairly efficient in that the plowing is, in the average case, well done, but on the other hand the further preparation of the seed bed is generally inadequate. Corn is now planted largely with check-row drills, which allow the crop to be cultivated both ways, and it is well worked during the early part of the season. Little hand hoeing is done, but a few farmers hoe their corn once. The corn crop is harvested early, in many cases, to allow the drilling of wheat. This involves a good deal of labor, as it is necessary to haul the fodder from the field before it is sufficiently cured for storage in barns, and it is usually stacked along the fences on all sides of the field after the corn is husked.

Farmers are well supplied with grain drills and modern harvesting machinery. Corn binders are rapidly coming into use, but the scarcity of hay tedders is surprising; and hay loaders are rare, though they might be used to advantage on large areas in the county.

Stable manure is carefully saved by painstaking farmers, but there are many careless exceptions. The manure is hauled to the fields twice a year, the comparatively small amount made during the summer being used in the fall for wheat, while that made during the remainder of the year is used in the spring for corn. Large quantities of low-grade commercial fertilizer are bought at a rate of from $11 to $16 a ton, and a few farmers use higher grades, which range in price from $18 to $23 a ton. The fertilizer is used for wheat at an average rate of 200 pounds to the acre, unless a light dressing of stable manure is used, when the amount is somewhat less. Corn is fertilized in a similar way, but the amounts used are, as a rule, somewhat less than for wheat. A dressing of 100 pounds an acre is also commonly applied for oats. The amount of fertilizer applied varies but little, though the grade thereof may vary much. In some sections in the western part of the county, on the Porters stony loam and the Porters clay, there is practically no manure or commercial fertilizer applied to corn, as it is deemed sufficient to plow under the sod of the preceding hay crop, especially if this be of clover. Considerable lime is burned in the limestone districts of the county, and the practice of applying lime to each field once in the course of several years still prevails, though to less extent than a few years ago.

Systems of crop rotation are in general use. The most common sequence is corn, oats, wheat, and grass. This rotation is varied somewhat by omitting oats altogether, since the rust has been so troublesome, and growing wheat two years in succession, or by substituting rye for the second crop of wheat. The general plan is to cut hay either one or two years, but fields are occasionally left in grass for several years and then pastured for a year or more.

AGRICULTURAL CONDITIONS.

The prosperity of the farming class of Adams County bears a close relation to the soil types upon which the farms are located. Farms situated on the limestone soils, the Penn loam, the least shaly parts of the Penn shale loam, and the copperstone phase of the Porters clay have, in most cases, the appearance of prosperity, while on the other soils the prosperous farmers constitute a minority. It is said that fifteen years or more ago the majority of the farmers were prosperous, and many became well to do; but since that time the profits have greatly diminished until the last two or three years, when there has been a slight tendency toward improvement of conditions.

The ownership of farms also has much to do with the prosperity of local agriculturists. The best farmers, who live on and till their own land, are notably thrifty, and by dint of rigid economy and remarkably long working hours for themselves and families secure a good rate of interest on their investment besides the living expenses of the family. Men who rent their farms seldom get a rate of interest on their investment equivalent to that paid by savings banks, and only an occasional tenant has anything left after paying the living expenses of himself and family.

The ratio of the number of farms occupied and tilled by the owners to the number of those worked by tenants is quite variable, not only in different parts of the county, but also in sections near together. If the county be considered as a whole, the estimate that 50 per cent of the farms are rented is probably safe. This ratio varies, however, within wide limits, and as given for many sections ranges from 25 to 75 per cent. Practically all of the renting is done under the share system. By the arrangement most common under this method, the tenant furnishes the labor, stock, tools, one-half of the seed, one-half of the commercial fertilizers, and pays one-half of the taxes, and receives one-half of all produce. If the owner furnishes the stock and tools, the tenant receives as his share one-third of the produce. In a few cases the owner furnishes everything and pays a stated salary to the tenant in addition to a partial interest in the crops. In some cases the tenant is required to furnish two-thirds of the commercial fertilizers, but in other cases only one-third, and in general there are many minor deviations from the above rules to fit special cases. The acreage of crops to be grown is stipulated in the agreement. The amount of stock to be kept by the tenant is also stipulated, and the owner usually takes care that the amount is sufficient to require that most of the tenant's half of stock feed shall be consumed on the farm. In other cases, where the stock is partially fed from undivided produce, the amount of stock to be kept is limited by the owner. The length of time which tenants occupy the same farm is exceedingly variable. In the limestone valley the average period is possibly as long as five years, and in rare cases farms are worked by the same tenant for fifteen or more years, but the number of tenants who stay on the same farm only one or two years is very large, and this makes the average for the county low. Of the real estate of the county probably three-fourths is unincumbered, and of the remaining one-fourth the average incumbrance is presumably less than 25 per cent of the value of the property.

Farms on the limestone soils range in size from 60 to 200 acres, with an average of about 125 acres. On the Penn and Cecil series of soils there are more small farms of from 40 to 60 acres each, and so, although farms of 200 acres are not uncommon, the average size is probably not over 90 acres. On the mountain areas the farms are smaller, the average being not far from 65 acres.

The farm buildings and improvements on the best soil types are, as a rule, excellent, and with the exception only of the poorest mountain districts and certain areas along the trap ridges they are good. The barns are large and substantial. The lower story is usually built of stone or brick and the superstructure of wood.

The dwellings are commodious and well built. Many are of stone obtained from the trap ridges. Bricks manufactured in the county are also extensively used in some sections. Both the dwellings and the barns are kept well painted and in good repair.

The prices of land range from $3.50—the price paid by the State for forest preserve in the mountains—to $125 an acre for well-improved limestone farms. There are considerable areas along the trap ridges and in the hilly or mountainous districts valued at from $10 to $20 an acre. Well-improved farms on the Penn loam are worth $30 to $60 an acre, and farms with similar improvements on the Penn shale loam are worth from $20 to $45 an acre.

The farm laborers hired in the area are nearly all natives of Adams or some adjoining county, and consequently are generally efficient for the work to be done. The only time when there is any scarcity of laborers is for short periods while crops are being harvested. During the harvest season day laborers receive $1.25 a day and board, but at other times during the summer from 75 cents to $1 a day. Good men receive $16 a month and board, for eight or nine months of the year. This decreases according to the efficiency of the workmen to $8 a month with board. In the winter season these laborers work for their board, go to the city, or wait for the next spring to appear.

The principal products of Adams County are wheat, hay, corn, and beef cattle. The secondary products are oats, apples, peaches, potatoes, hogs, sheep, poultry, and crops for the canning factory. The relative importance of these farm products varies in different parts of the county and fluctuates to a considerable degree in every section. Wheat, which has been the chief money crop for many decades, still maintains that important position, and in acreage far exceeds any other crop save hay. Local flour mills grind the principal part of the wheat needed for local consumption. The straw, at the time of thrashing, is stacked in large piles in the barnyards. There cattle utilize a part of it as roughage and the rest is trampled with the manure.

Nearly all farmers sell some hay, and many sell large quantities of it, while a few, discouraged by the low prices of wheat in former years, depend upon it as the principal money crop. Corn is the crop of next importance, and many sell the greater part of their yield. Others buy 2 and 3 year old steers, which are brought to the county, principally from Virginia, by drovers. This plan is pursued by many for the sake of having stable manure with which to maintain the fertility of their farm lands. As long as this was profitable farmers were glad to follow this plan, and to have the manure in return for their winter's labor, but the failure to realize anything, or but a nominal return, for the corn crop when thus disposed of has led many to stop buying steers, and to sell their corn. The desire to maintain the fertility of the soil, however, prompts nearly one-half of the farmers to take the risk and fatten from 3 to 15 steers each winter.

The greater part of the milk is hauled to skimming stations located at or near railway stations, and sold by the Babcock test to the operators of proprietary creameries. The cream is then shipped to cities for retail trade, or to a creamery outside of the county, where it is made into butter. Other small proprietary creameries are located within the county. Nearly one-half of the farmers make butter at home and dispose of it at the local stores at a very low average price. A few enterprising farmers, by producing a superior grade of butter, have effected a steady sale of their products to dealers in Philadelphia at satisfactory prices. This method, though limited in scope, affords probably the most remunerative disposition of dairy products in the county, and illustrates an opportunity of which those who understand how to make an excellent product might well avail themselves. The inauguration of cooperative creameries among farmers offers also a solution for the satisfactory manufacture and sale of dairy products. This system has proved eminently successful in some parts of the country, and would seem to be worth while in Adams County, where the dairy industry is poorly developed chiefly because of the unsatisfactory returns for its products. A marked improvement in the standard of herds would be essential, however, before the dairy industry could be very profitable.

Oats were formerly an important crop and were used in almost every rotation, but the uncertainty of the yield in recent years, particularly on account of the rust and the consequent inferiority in quality, has greatly reduced the production of this crop. Small quantities of barley are also grown.

Large quantities of apples are grown along the foot of South Mountain near Cashtown and from there toward Bendersville. The fruit has been of excellent quality and gave promise of the extensive development of the industry in that section, but the scale has already obtained a strong foothold in some of the orchards, and unless this pest be combated by the use of sprays and washes the extension of the apple industry is seriously threatened.

Peach orchards are scattered all over the county, and if good markets were more accessible, or if adequate shipping facilities could be introduced for the proper transfer of this fruit to market, its production would be increased and attended with profit. Under the present market conditions the crop is generally considered unprofitable.

Many small flocks of sheep are seen, but the number seems to be decreasing. Nearly every farmer sells a few hogs each year, and some have made this an important adjunct to their other farming operations. Others derive a considerable income from poultry.

A canning factory at Littlestown uses the sweet corn obtained from 600 to 800 acres grown in this county, and also a few peas and beans, but the most of the latter products canned are obtained below the Maryland line. In many places in the vicinity of farm dwellings the roads are lined with sweet cherry trees. These bear abundantly, but there is practically no market for them, and those not utilized at home mostly go to waste.

The adaptation of soils to crops receives almost no attention throughout the county, and, with the exception of the care used in the selection of soil for growing potatoes, and in some instances for fruit, the same crops are grown on all soils, unless the conditions of drainage in certain areas seriously interfere.

The transportation facilities of the county are not adequate for the full development of its agricultural interests. The Western Maryland Railway crosses the county from east to west, connecting it with

Baltimore and Philadelphia, and the Gettysburg and Harrisburg Railway extends from the center of the county north to Harrisburg. The Frederick branch of the Northern Central Railway crosses the southeastern corner of the area, connecting Frederick, Md., with York, Pa. Large areas in the county are thus left a long distance—6 to 12 miles—from a shipping point. No important electric lines have been built. A short line has been constructed at Gettysburg, so as to include that part of the battlefield most interesting to visitors, and a still shorter line connects McSherrystown with Hanover, in York County, a distance of 2 miles. Several toll turnpike roads cross the county, and although these are an advantage when the mud is deep, they are so rough during the summer season that the common dirt roads are preferable.

Baltimore and Philadelphia are the principal markets, the former receiving the greater part of the grain, hay, and cattle, while the latter is the best market for fruit, butter, and poultry.

SOIL SURVEY OF APPOMATTOX COUNTY, VIRGINIA.

By THOMAS A. CAINE and HUGH H. BENNETT.

LOCATION AND BOUNDARIES OF THE AREA.

Appomattox County is situated in the south-central part of Virginia. It is bounded on the northwest by the James River, which forms the boundary separating Appomattox from Amherst County; on the northeast by Buckingham County; on the southeast by Prince Edward and Charlotte counties; and on the southwest and west by Campbell County. The present survey includes the entire county and covers an area of 217,792 acres, or approximately 340 square miles.

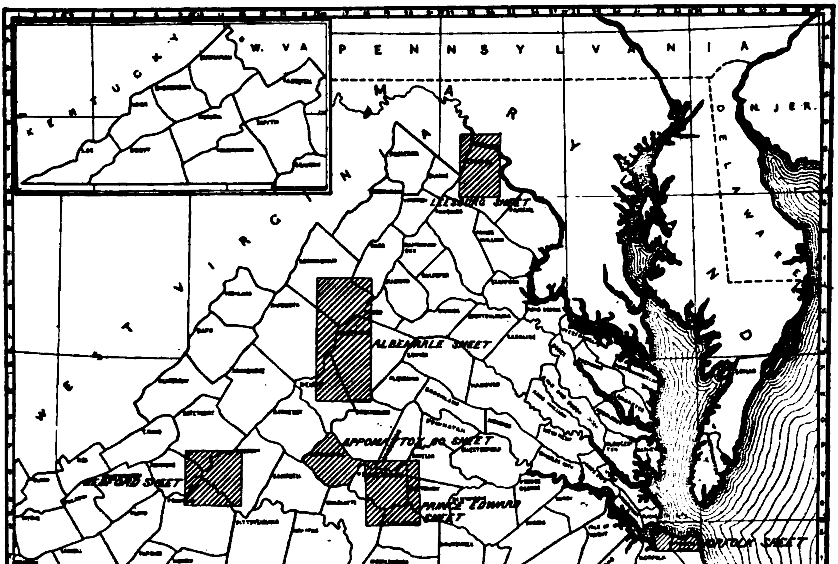

FIG. 4.—Sketch map showing location of the Appomattox County area, Virginia.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Appomattox County was organized in 1845, having been formed from parts of Buckingham, Campbell, Charlotte, and Prince Edward counties. The region was originally settled by colonists, mostly

English, with a few Huguenots, Germans, and Irish. The descendants of these and a few families who have come from the west and north since the civil war constitute the white population of the area at the present time. During the slavery period the population was about equally divided between whites and colored, but in recent years, owing to the better wages paid elsewhere, especially in the coal fields, the colored population has decreased. The white population has increased, but the population as a whole has gained little in the last decade.

Even in the early days the area was practically self-sustaining. There were several large plantations and each of these formed practically an independent community. Flax, cotton, and wool were produced, spun, woven, and made into clothing, but tobacco, wheat, and corn were the principal crops grown, and some live stock was raised. The live stock was driven to Richmond and sold, the corn was consumed at home, while the wheat and tobacco were either marketed in Lynchburg or carried to points upon the James River and shipped in flatboats to Richmond. The construction of the James River and Kanawha Canal and later the laying of the Norfolk and Western Railroad gave a decided impetus to farm operations in the area.

Appomattox County has become historical because of the fact that within its borders was enacted the last scene of the war between the States, when, at Appomattox Court-House, Lee surrendered his army to Grant, on April 9, 1865. As a result of the war some of the former slave owners found themselves with practically no capital and no efficient labor with which to resume their farming operations. They were, in fact, "land poor," and were able to cultivate only a part of the cleared fields, large areas being abandoned to grow up to old-field pine or to be subjected to severe washing and gullying. Not being able to adjust themselves readily to the changed conditions, many were obliged to sell their lands at a sacrifice, either to pay the debts contracted before the war or to satisfy the tax claims. It thus happened that the large plantations were divided into smaller farms, which gradually fell into the hands of either those who in antebellum days were the working people or those who have grown up under the changed conditions. There are a few negroes in the area who own small tracts of land. At the present time the wealth of the county is more evenly distributed than formerly. The farms are smaller and are owned largely by people who do their own work.

CLIMATE.

The proximity of the area to the mountains makes cotton growing unprofitable, and none is at present produced. The climate is favorable to the growing of wheat, corn, oats, tobacco, fruit, and vegetables, and to the raising of stock. Stock has to be housed only about three months of the year.

The normal annual precipitation is about 43 inches. The precipitation is uniformly distributed throughout the year, but during the growing season crops sometimes suffer because of periods of drought.

The altitude of the area is not quite sufficient for the best results in apple and peach growing, on account of the late frosts in the spring. On the highest points and on the small elevations away from the streams the best results are obtained. The trouble with the lower locations is that the cold air settles in them, and frosts are more likely to do damage when the trees are in bloom. There are no extensive areas in the county which are high enough to be above the "frost line."

The following table shows the normal monthly and annual temperature and precipitation at Lynchburg. This station of the Weather Bureau is situated in Campbell County, at an elevation of 524 feet, which is not far from the mean elevation of Appomattox County:

Normal monthly and annual temperature and precipitation.

Month.	Lynchburg.		Month.	Lynchburg.	
	Temperature.	Precipitation.		Temperature.	Precipitation.
	° F.	*Inches.*		*° F.*	*Inches.*
January	36.8	3.95	August	75.3	4.01
February	40.0	3.58	September	69.0	3.81
March	45.2	3.67	October	57.1	3.26
April	55.9	3.36	November	46.8	2.94
May	66.0	3.91	December	39.3	3.05
June	74.2	3.46	Year	57.0	42.85
July	78.4	3.90			

PHYSIOGRAPHY AND GEOLOGY.

Appomattox County is located in the Piedmont Plateau and belongs to the geographic division of the State known as Middle Virginia. As viewed from the nearby mountains to the northward, it has the general appearance of an eroded plain, but in traveling across the area its surface is seen to be greatly eroded, hilly, and cut by the channels of many streams.

The area is drained in the north by the James River, and in the south by the tributaries of the Stanton River. The divide between these two river systems is a ridge crossing Appomattox County from Concord to Pamplin City. The altitude at Concord is 840 feet, while that at Pamplin City, about 25 miles southeastward, is 678 feet.

The influence of the James River along the northern boundary of the county has greatly modified the usual topography of the plateau. The valleys are comparatively wide, but instead of the broad, gently rolling interstream ridges characteristic of the plateau, they are usually narrow, sometimes greatly eroded, and rough, making many of them undesirable for general farming. The altitude of the James River is less than 450 feet, so that the streams north of the divide have a fall of from 200 to 400 feet within a distance varying from 10 to 20 miles. South of the divide the tributaries of the Stanton River leave the area at an altitude of about 500 feet, but the fall is more uniform, the interstream ridges are broader, leveler, and less dissected than those north of the divide, and hence more desirable for agricultural use. The highest points in the county are Pine and Pilot mountains, which rise to an altitude of 1,050 feet so that within the area there is a range in elevation of over 600 feet.

Throughout the area the roads follow the ridges. The difference in elevation between the ridges and the streams varies from 50 to 275 feet, and it is more difficult to haul heavy loads long distances than would have been the case if the roads followed the valleys, where the grades could be made more uniform.

As would be expected in a region of such differences in elevation, the streams are too rapid and their courses too narrow to favor the accumulation of extensive sediments, hence the amount of bottom land or meadows is less than is usual for a Piedmont section.

The greater portion of the area is underlain by talcose and mica schists in which the particles of mica are very fine. Intermingled with these schists are small quantities of siliceous material which upon weathering imparts to the soil a sandy nature. The soil derived from the schists is principally the Cecil sandy loam, with occasional patches of Cecil clay. The sandy soil is usually found in all locations, from the gently rolling uplands to some of the steeper slopes. In a few locations, as for example, upon the narrow ridges and upon the steeper slopes where erosion has been more rapid than weathering, the sandy top soil has been washed away exposing the red subsoil of the Cecil sandy loam and giving it the appearance of the Cecil clay.

There are parts of the area underlain by a fine-grained, dark-colored gneiss, of which there are two varieties, the hornblendic and the chloritic. When the underlying gneiss contains considerable quartz it weathers slowly, forming hills which are usually covered with the typical Cecil clay, as in the vicinity of Appomattox. In localities, however, where the quartz is much less abundant the underlying rocks weather into gently rolling or nearly level areas, which are occupied by the Iredell clay loam. When the underlying gneiss abounds in chlorite the resultant soil, the Iredell clay loam, is remarkable for its greenish colors.

SOILS.

There is not great variety in the soil material covered by this survey, and it was possible to classify it with six types already established by earlier surveys of the Piedmont Plateau. Of the entire area 77.5 per cent is occupied by one type, the Cecil sandy loam, and 14.5 per cent by the closely related Cecil clay; thus 92 per cent of the county is composed of but two distinct soils.

The following table gives the name and extent of each of the six soils to be described later on in this report, while the accompanying map shows the location of the various areas by means of different colors and symbols.

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Cecil sandy loam	168,768	77.5	Cecil loam	1,406	0.6
Cecil clay	31,232	14.5	Cecil sand	960	.4
Iredell clay loam	9,664	4.4	Total	217,792	
Meadow	5,760	2.6			

CECIL SANDY LOAM.

The soil of the Cecil sandy loam is a gray or brownish gray fine to medium textured sandy loam, ranging in depth from 4 to 15 inches. The subsoil is a red sandy clay, grading quickly into red clay, which becomes stiffer in the lower depths. Owing to the presence of many fine particles of mica and talc, the subsoil usually has an oily feel. At a great depth the subsoil grades gradually into the underlying disintegrated micaceous and talcose schists of the region.

The Cecil sandy loam is the most widely distributed type of the area. It is found in all locations from the tops of the ridges to the stream bottoms, and its topography is quite varied. Extensive areas on the slopes of the hills and ridges have never been under cultivation, largely for the reason that the soil is too thin, having a depth of only 4 or 5 inches, and is susceptible to drought on account of its slight water-holding capacity. It is also too steep and hilly to cultivate with ease, and the soil soon washes away, exposing the subsoil. Such areas are covered with black-jack oak, principally. In the leveler locations, usually away from the narrow ridges, the soil has an average depth of 8 inches or more, and the moisture conditions are much better. For this reason and also from the fact that it receives some of the seepage water from higher ground, there is less likelihood of drought, and larger areas are under cultivation.

The Cecil sandy loam, owing to its hilly topography, is naturally well drained. In fact it is apt to be too well drained, and even in the most favorable locations there is need of the addition of an abundance of organic matter to make the soil sufficiently retentive of moisture to sustain crops during a dry season.

This type is a residual soil derived from the weathering of the underlying mica and talcose schists. The rock is usually weathered to a great depth and seldom appears on the surface except upon narrow, eroded ridges, in road cuts, and along stream bottoms.

The principal crops grown are heavy export tobacco, wheat, corn, and clover. Tobacco yields upon an average about 500 pounds per acre, although double that quantity may be produced by heavy fertilization and the best methods of cultivation. Wheat, when grown after tobacco, yields between 15 and 20 bushels per acre, but when grown after corn, yields only about 8 or 10 bushels per acre. The larger yield secured when following tobacco is due, it is believed, to the benefit received from the fertilizers applied to the tobacco crop. The average yield for corn is from 15 to 20 bushels per acre, although much larger yields are possible. The clover crop is usually light, and is grown more for its beneficial effects on the soil than for feeding purposes.

The following table gives the results of mechanical analyses of typical samples of the Cecil sandy loam:

Mechanical analyses of Cecil sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12208	Chap	Gray sandy loam, 0 to 10 inches.	1.8	10.1	7.3	21.7	16.4	31.5	11.4
12206	1¼ miles NE. of Hixburg.	Gray sandy loam, 0 to 12 inches.	2.1	8.7	7.0	20.9	19.6	28.7	13.1
12207	Subsoil of 12206	Red clay, 12 to 36 inches	1.4	6.0	4.6	16.6	15.4	20.6	34.9
12209	Subsoil of 12208	Red clay, 10 to 36 inches	.6	3.7	2.6	7.2	6.9	16.9	61.5

CECIL SAND.

The Cecil sand, to a depth of from 15 to 18 inches, is a gray, light sandy loam of medium texture. The subsoil is a bright yellow sandy clay, reaching to a depth of 30 inches or more. Disseminated through both soil and subsoil are considerable quantities of broken quartz rock, which, however, is not plentiful enough to interfere with cultivation. In the present survey the type does not occur in its most typical form and is found only in small patches, principally in the eastern part of the area near Pamplin City. It is confined to the uplands and occupies the more level parts of the interstream ridges, and owing both to its location and the open texture of the soil and subsoil it is naturally well drained. The abundance of sand is due to the fact that the soil is derived, in situ, from a highly siliceous mica schist, through which are scattered many small veins of quartz.

The areas occupied by this type are mostly wooded. Where cultivated, fair crops of corn, oats, and wheat are produced. No tobacco was seen growing upon it. The average yield for corn is about 15 bushels, and for wheat about 10 bushels. The oats are fed in sheaf.

The following table gives the results of a mechanical analysis of the fine earth of the Cecil sand:

Mechanical analysis of Cecil sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12202	1 mile N. of Pamplin City.	Gray light sandy loam, 0 to 18 inches.	1.7	9.0	8.5	33.0	16.6	22.5	8.5
12203	Subsoil of 12202......	Yellow very sandy clay, 18 to 30 inches.	1.4	7.2	7.2	26.6	12.1	21.0	24.4

CECIL CLAY.

The soil of the Cecil clay is a red loam or clay loam, ranging in depth from 4 to 8 inches. The subsoil is a stiff, tenacious red clay to a depth of 3 feet or more, with the clay content usually increasing in the lower depths. There is generally considerable quartz or hornblende gneiss strewn upon the surface and mixed with the soil, but these rock fragments do not occur in sufficient quantities to interfere seriously with cultivation.

The Cecil clay, in the present area, occurs principally upon the slopes adjoining the larger streams, but it is also occasionally found upon the divides. Owing to its location it is rolling and in places rather hilly and broken, and for these reasons possesses good natural drainage. Unless the soil is kept in good condition for retaining moisture by deep plowing and by incorporating with it an abundance of organic matter it is apt to be droughty. It also has a tendency to wash badly.

It is a residual soil, derived both from micaceous schist and the hornblende gneiss. Small veins of quartz are found in these rocks, and fragments of the quartz which have resisted the agencies of weathering are often scattered upon the surface and through both soil and subsoil. The brownish red loamy phase of the type, locally known as "chocolate," or "push land," is the loamy surface material washed from the higher elevations, and consequently is deeper and more loamy than the typical Cecil clay. It is upon an area of this phase of the type about 3½ miles northeast of West Appomattox that the Bureau of Soils is carrying on tobacco experiments.

This type is regarded as the best soil in the area for general farming. It is especially well adapted to the production of heavy export tobacco, and an excellent quality of plug wrapper, which is not exported, the yields of which range from 500 to 1,500 pounds per acre, depending upon the location, fertilization, and the methods of cultivation. The average yield, however, with the usual methods is about 700 pounds per acre. Wheat grown upon the same land after tobacco yields sometimes as high as 35 bushels per acre, but 20 bushels is about the average in good seasons. The average yield for corn is about 25 bushels. Tobacco and corn are not grown upon the same land. Corn is not fertilized as heavily as tobacco, and consequently the average yield per acre for wheat after corn is only about 12 bushels. When a stand can be obtained, clover does fairly well and is very beneficial to the soil. Cowpeas produce well, but are grown more to improve and enrich the soil than as a forage or fodder crop.

The following table gives the results of mechanical analyses of typical samples of fine earth of both soil and subsoil of the Cecil clay:

Mechanical analyses of Cecil clay.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12210	1 mile N. of Hixburg.	Red loam, 0 to 8 inches...	1.0	5.5	8.8	37.0	8.0	14.9	24.7
12216	Experiment farm ...	Red clay loam, 0 to 7 inches.	.9	3.2	2.7	13.2	25.0	30.0	24.7
12214	Appomattox.........	Red clay loam, 0 to 8 inches.	2.7	7.6	4.9	10.6	9.1	34.8	29.8
12211	Subsoil of 12210......	Red clay, 8 to 36 inches.	1.4	4.9	6.6	29.2	5.8	12.4	39.6
12217	Subsoil of 12216......	Red clay, 7 to 36 inches...	.6	1.3	1.1	6.9	11.1	24.4	54.5
12215	Subsoil of 12214......	Red clay, 8 to 36 inches...	.6	1.7	1.7	4.9	5.3	30.3	55.3

CECIL LOAM.

The soil of the Cecil loam is a grayish or yellowish loam with an average depth of 10 inches, containing 10 to 15 per cent of the coarser grades of sand. There is considerable silt in the soil which, in places, gives it a compact structure. In the wooded areas there is considerable coarse gravel and siliceous fragments of mica-schist scattered upon the surface. The subsoil is a yellowish or reddish loam or clay loam, usually having an oily feel, which is probably due to the presence of talc and very fine particles of mica. This material changes into decomposed mica and talcose schists at depths varying from 2½ to 6 feet. Throughout both soil and subsoil and often scattered upon the surface are fragments of the underlying schists and quartz, and occasionally upon the crests of hills the underlying rocks come to the surface.

This type of soil is found only in small areas and is confined to the highest parts of the county, ranging from 800 to 1,050 feet above sea level. Its topography is hilly. and the natural drainage good. It is a residual soil derived from impure siliceous mica and talcose schists, which have been more resistant to the agencies of weathering, and hence stand at a greater elevation than the surrounding plateau.

The Cecil loam has never been under cultivation in the present area. It is held in low esteem and has been sold as low as 50 cents an acre. The usual price, however, is about $2.50 an acre. The type supports a scanty growth of oak, chestnut, and laurel. It is recommended that orcharding be extended to these higher elevations, where it is thought that the fruit trees will suffer less from frost in the spring than they do in many areas where now grown.

The results of mechanical analyses of typical samples of the fine earth of the Cecil loam are shown in the following table:

Mechanical analyses of Cecil loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12224	4 miles S. of West Appomattox.	Loam, 0 to 12 inches	8.1	8.2	2.9	9.7	11.5	40.6	19.1
12226	Pine Mountain	Gray loam, 0 to 10 inches.	4.4	5.8	3.4	12.8	11.3	41.4	21.6
12225	Subsoil of 12224	Loam and clay loam, 12 to 40 inches.	9.7	11.2	3.7	12.0	9.4	27.1	26.9
12227	Subsoil of 12226	Loam to clay loam, 10 to 36 inches.	7.8	12.2	4.5	11.1	6.6	25.6	32.1

IREDELL CLAY LOAM.

The soil of the Iredell clay loam is a yellowish-brown to dark-brown loam, with an average depth of about 10 inches. Though usually loamy, in some places it is rather sandy and tends toward a sandy loam. Iron concretions about one-fourth inch in diameter, locally known as "black gravel," are often strewn upon the surface and incorporated with the soil. Besides these there are often present fragments of quartz and gneiss, locally known as "black rock." The line of demarcation between the soil and subsoil is very distinct. The latter is a sticky, waxy, plastic, impervious, yellow clay, usually free from gravel or rock fragments, and passing gradually into disintegrated hornblende or chloritic gneiss at depths varying from 2½ to 5 feet.

This type occurs in limited areas principally in four localities, viz, in the eastern part of the area between Pamplin City and Hurtsville; in the central part near Appomattox; in the western part 2 miles south of Concord, and north of Concord in the vicinity of Stonewall Creek.

The Iredell clay loam is found typically developed upon the table-lands between the streams and ridges and is conspicuous for its nearly level or gently rolling topography. Where these table-lands pass into higher lying areas of the Cecil clay or the Cecil sandy loam the type is usually hilly and broken, and while the soil still possesses its loamy qualities, the stiff, plastic, impervious characteristics of the subsoil almost entirely disappear, as is the case in the Rocky Hill region, 3 miles north of West Appomattox. In the hilly area the drainage conditions are good, but upon the table-lands, owing both to lack of fall and the character of the subsoil, the drainage is naturally poor, and in such areas artificial drainage would undoubtedly prove beneficial. In the level locations the land is cold and late in the spring, while in a dry season it suffers from drought.

This type is also a residual soil, derived from the weathering of hornblende or chloritic gneiss, and where the latter rock predominates it imparts to the soil a pronounced greenish color. The underlying rock is usually encountered at from 2½ to 5 feet below the surface, and in hilly areas the surface is occasionally so thickly strewn with rock fragments as to interfere with cultivation.

In its present unimproved condition the type is not unusually well adapted to any crop. With careful preparation and proper cultural methods fair crops of corn and oats can be produced. In the most favorable locations tobacco does fairly well. The yield is sometimes satisfactory, but the leaf is coarse and "bony." In the more hilly areas in the rocky phase of the soil winter wheat does fairly well, but upon the flatter area this crop winter kills. From the appearance of apple trees upon the same phase, it would seem that orcharding might be profitably extended.

In the leveler areas the effects of fertilizers are not so lasting as would be expected with such a stiff, impervious subsoil, and crops show scarcely any effect after the first year.

The results of mechanical analyses of typical samples of the fine earth of the Iredell clay loam are shown in the following table:

Mechanical analyses of Iredell clay loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12220	½ mile NW. of Hixburg.	Brown loam, 0 to 10 inches	11.9	9.1	3.0	15.6	23.9	27.9	8.1
12218	2½ miles NW. of Pamplin City.	Brown loam, 0 to 10 inches	7.6	7.8	2.6	17.9	24.6	28.8	11.2
12221	Subsoil of 12220	Yellow clay, 10 to 36 inches	2.0	2.9	1.9	11.1	10.2	31.7	40.2
12219	Subsoil of 12218	Yellow clay, 10 to 36 inches	1.5	2.8	1.9	10.5	10.7	20.9	51.7

MEADOW.

The areas classed as Meadow are composed of such various materials that it is impracticable to give a succinct and definite description of the type. In general, the narrow bottoms are made up quite largely of sand and have either the texture of a sandy loam or a loam, while the wider bottoms are less sandy and the soil is more often a loam or silty loam. There is one phase of the type, locally known as "crawfish land," which occurs in spots too small to be mapped. Here the soil is a loam or sandy loam and is underlain by a "blue pipe-clay," which is quite impervious to water.

The extent of Meadow in this county is less than is usually the case for a Piedmont section. Bottom lands are not found along all of the streams, though only along a few of the larger streams, like the Appomattox River, are there wide areas.

All of the Meadow is flat, or nearly so, and is subject to overflow. In the case of the narrow sandy bottoms there is seldom any difficulty with drainage, but upon the wide bottoms, where the flood waters spread out over larger areas and where sediments are necessarily finer, artificial drainage is necessary. This is usually accomplished by large, deep, open ditches, and sometimes by plowing the fields in narrow lands. In order to protect the bottom land from the wash of the higher adjoining hills, deep ditches leading to the streams are sometimes constructed along the base of the hills. The "crawfishy" spots would be greatly benefited by artificial drainage, but it is doubtful whether expenditures for this purpose would be economical.

The Meadow is still in the process of formation whenever the streams overflow their channels. Some of the streams are still rapidly eroding their channels, and hence their courses are too narrow and their currents too swift to favor the accumulation of sediments.

Valuable Meadow areas have been greatly damaged along the Appomattox River during the last few years by erosion during freshets.

The Meadow is regarded as the best land in the area for corn, and the opinion prevails that farms which have no areas of Meadow are not the most desirable. The average yield per acre for corn is from 50 to 60 bushels, and much larger yields are not uncommon. It is also excellently adapted to grass and pasture, but is little used for such purpose because of its demand for the production of corn. Large yields of tobacco can also be produced on this soil, but the texture is usually too coarse, and this crop is not grown except in a few of the more sandy areas. The " crawfishy " spots are not usually desirable for any crop or for pasture.

AGRICULTURAL METHODS.

The war left the farmers with so little capital and controllable labor that large areas of cleared land were " turned out " to be subject to severe washing and to grow up with old-field pine, and while this led necessarily to the cultivation of smaller areas better methods of cultivation did not immediately follow.

Aside from the attempt to cultivate too much land, a decided hindrance to success has been the use of wasteful methods and a lack of thoroughness in the preparation and cultivation of the soil; and some large plantation owners have trusted the cultivation of their lands entirely to tenants, a practice that almost always leads to soil exhaustion.

In the case of tobacco, for example, many farmers do not plow the land until spring, and then the plowing is shallow, and the tobacco is planted upon ridges. On the other hand, the cultivation throughout the season is deep, which tends to break up the root system and to injure the plants. A much better plan, and the one pursued and recommended by the Bureau of Soils in its experiments on the farm 3½ miles northeast of West Appomattox, is to plow the land to a depth of 6 or 8 inches in the fall, great care being taken not to plow when the ground is wet, thus avoiding baking and clodding, and immediately after plowing to sow some winter cover crop, like rye, which is harrowed in lightly. This not only allows the ground to get the benefit of frost action in fining and mellowing the soil during the winter, but the rye serves the double purpose of keeping washing in check during winter rains and of adding humus to the soil for the next crop. The rye is turned under in the spring when it is about 6 inches high, and the ground is thoroughly pulverized with a disk harrow. The first cultivation of the tobacco is deep, so as to thoroughly loosen up the ground, but thereafter all cultivations, which follow at intervals of one week apart until the plants are ready to top, are shallow enough to avoid breaking the roots and retarding the development of the plants.

Home mixed fertilizers are recommended, and a heavy application of these is advised. But the details of this work may be learned by those interested in the area by visiting the farm referred to, or later when they will be given in published form. It may be mentioned, however, that the first experimental crop has shown that the average yield of 600 pounds per acre may be increased to 1,300 pounds, and that while the first expense of fertilizers is rather heavy, the increased yield of other crops in the rotation will more than make up for it.

The scanty application of barnyard manure, coupled with a continual growth of clean cultivated crops, has so reduced the humus content of the soils of the county that many originally fine farms have been "worn out"—i. e., become unprofitable to cultivate under the present methods. All unoccupied lands should be protected from the washing of winter rains by some cover crop like rye or vetch. Cowpeas should be grown extensively upon all of the types. They may be plowed under or cut for hay, provided the latter is returned to the soil later as manure. The roots of the peas not only add nitrogen to the soil, but change its mechanical condition by making it more loamy.

Within the areas of Cecil clay there are often small shallow, hard, compact areas locally known as "gall spots." After a few hours of rain they become a mire, and in dry weather they get as hard as a brick. These "gall spots" are unproductive, because there is no organic matter in the soil and their water holding capacity is very small. By growing cowpeas and winter cover crops for a few years they may be made mellow, loamy, and productive.

The farmers of the county raise too little of the necessaries of life. Every farmer can and should raise hogs and sheep and sell bacon, hams, mutton, and wool. There is a great demand for good mules and horses. These and some cattle should be raised upon every farm. The advisability of keeping more stock is strongly urged, not only because of the value of stable manure, but also because of the beneficial effects of pasturing the land. All land of the area when "turned out" reverts to its original condition if it is not pastured. It should be kept in mind, however, that it is not advisable to pasture seeded land until after the second year, because the tramping of stock is very injurious both to the land and the young plants. Care should also be taken not to turn the stock upon the land when it is very wet.

AGRICULTURAL CONDITIONS.

Since the war the lands have fallen largely into the possession of those who were formerly working people. These were the ones under the changed conditions best fitted to develop the resources of the region.

The narrowness of the "bottom" lands has limited the corn and hay growing capacity of the area and necessitated to some extent the importation of these products. The extensiveness of the "thin" phase of the Cecil sandy loam has also been a drawback, and owing to the difficulty of getting a stand of timothy and clover the region is deficient in stock, and hence also deficient in barnyard manure, which is needed to maintain the productivity of the soils. The practice of manuring so largely with doubtful brands of commercial fertilizers bought upon credit, together with the practice of buying home supplies upon credit at prices fixed to include an exorbitant rate of interest, has also done much to retard the prosperity of the farming class. The credit system is the natural outgrowth of one-crop farming and the lack of diversification. No one thing is needed more in this area than a greater diversification in farm crops.

Despite the conditions just described, there are good opportunities for those who use judgment in selecting farms and who are willing to do their own work. Some of the tenant class who learned from actual experience how to grow and cure tobacco have been known to purchase and pay for a farm in two years. Those who have used good judgment in selecting farms, have managed them with a view of keeping the soil in the best condition, and have not purchased supplies upon credit are generally prosperous.

There are indications that the area is entering upon an era of greater prosperity. Very few farms are mortgaged, the natural conservatism of the people is disappearing, and more attention is being paid to agricultural methods approved by modern experience. The value of green manuring crops, for instance, is more thoroughly appreciated. The public schools are being improved. There is more of a spirit of cooperation among the farmers, and the rural free delivery is bringing them in closer touch with the rest of the world.

About 60 per cent of the farms are operated by the owners, about 25 per cent by share tenants, and the remainder by cash tenants and part owners. In renting, the usual custom is for the owner to furnish the tools, teams, and feed, and half of the fertilizer, receiving in return half of the crops grown.

The farms range in size from a few to 1,000 or more acres, with an average of about 150 acres. At present there is a tendency toward increased acreage, caused by the more prosperous farmers buying adjoining lands, not so much with a view of increasing their area under cultivation as for investment. Some of the colored people are small land owners, the size of their farms usually ranging from 10 to 35 acres, while a few have holdings as large as 150 acres.

The usual size of the farms throughout the area is too large, but can not be greatly decreased without an increase in population. Probably not more than 25 per cent of the area is at present under cultivation. There is very little of the original timber in the region, however, the black oak and chestnut oak having been removed years ago for tan bark, and the post oak, in recent years, for cross-ties. The wooded areas at present consist mostly of black-jack and other oaks, second-growth pine, chestnut, and hickory.

Land values range from $2.50 to $20 an acre, the average for fair farming lands being about $10. The abundance of cheap land is attracting farmers from the North and West. Those newcomers of limited means who are not acquainted with the conditions and methods in use would do well not to attempt farming upon their own account at once. The history of such attempts is mostly one of discouragements and failures, which might be avoided if intending settlers would work for a year or so with an experienced farmer; for no matter how poor his methods appear the native farmer is apt to know more of the conditions and how best to meet them than a stranger can possibly know. The latter, however, may soon learn to improve upon those methods after he has become acquainted with the seasonal changes, the best time of planting, and other elementary questions connected with the local industries. An ideal farm for the region is one that has an abundance of Cecil clay upon the uplands for growing tobacco and grain and sufficient bottom land to grow corn and hay for home use.

Until about a decade ago the colored people constituted about half of the laborers of the area. During the past few years there has been a great scarcity of negro labor, owing to the fact that the most efficient have gone to the near-by coal fields, where better wages are paid. The majority of those remaining are either the less skillful laborers or those owning small farms and not obliged to work for others. Efficient farm hands have become all the more scarce in recent years because many of the industrious white class who were formerly laborers now have property of their own.

The lack of labor is largely responsible for the small proportion of land under cultivation in the county. It appears that if the agricultural possibilities are to be fully developed some kind of labor, foreign or domestic, must be induced to come into the county, and before the most desirable class of labor can be attracted the wages paid in other parts of the country must be more nearly approximated.

The present low wages not only exclude the best laborers, but tend to discourage the laborer home-seeker. The only solution of the problem lies in establishing a diversified system of farming, instead of depending almost entirely upon one crop as a source of revenue. In this way money will be coming in at different times of the year; more money will be in circulation; there will be greater prosperity, and better wages can be paid.

Tobacco has been the chief product for many years and is at present practically the only money crop of the area. An excellent variety of export and dark plug wrappers is at present the only tobacco grown. It is cured in barns over fires usually made of green oak, chestnut, or hickory, and the results obtained, as well as the prices received, depend in a large measure upon climatic conditions and the skill of the growers, some of whom seem to have far greater success than others under similar conditions.

Winter wheat was formerly grown quite extensively and considerable quantities were shipped, but competition with grain grown in the Northwest has resulted in a reduction of the acreage, until now scarcely enough is grown to supply the local demands. Corn and oats are among the principal products and good yields are obtainable, but not enough of these crops is grown in the area to supply its demands. Clovers, with timothy or herd's-grass, are grown for hay, but the great difficulty of getting a satisfactory stand makes them unpopular with many. Large quantities of feed are shipped in annually to supplement the production of hay and corn. Vegetables and potatoes are grown, but scarcely enough to supply the home needs. Several varieties of apples, good in keeping qualities, color, and size, are grown by a few and sold at a profit.

The crops of the area are well adapted to the soil types upon which they are grown. The Cecil clay is especially adapted to a good dark leaf tobacco suited for plug wrappers, and it also produces an excellent quality of export tobacco, as well as good yields of wheat and corn. It is the only type in the area upon which clover makes a satisfactory stand, and it should be used more extensively for this and other leguminous forage crops.

The deeper phase of Cecil sandy loam, when properly handled, produces a fair quality of heavy export tobacco, and it will also produce a bright tobacco; but as the near-by markets do not demand the latter type, none is grown. In general, it may be said that the tobacco grown upon Cecil sandy loam is a thinner leaf, with coarser fiber than that grown upon Cecil clay. Wheat and corn are grown upon this soil, but the yields are naturally smaller than upon the Cecil clay. Fair yields of oats are secured upon both the Cecil clay and Cecil sandy loam.

Iredell clay loam is not well adapted to growing tobacco, because it produces too "bony" a leaf. Owing to the usual impervious nature of its subsoil, it "heaves" in the winter and hence is not adapted to wheat. The yields for corn and oats are usually fairly satisfactory, and the type is used mostly for these crops and also for pasture. The few "black rock" outcrops associated with this type are more loamy and better adapted to all crops, and especially to apples.

Meadow is the best type in the area for corn, and adjoining the hills, where the type is inclined to be more loamy, it often produces an excellent heavy export tobacco. Small experimental patches of nonsaccharine sorghum were seen growing in such a way that an extension of these experiments is advised upon the type.

Cowpeas and vetches are well adapted to all types of the area, and too much stress can not be laid upon the advisability of growing them, both as forage and green manuring crops. The vetch is an excellent winter cover crop. Brome grass and herd's-grass are the native grasses of the region. Clover and timothy are unsatisfactory because they are short lived. Vegetables and potatoes do well upon any of the types. With the greatest care and attention and in the most favored locations apples may be grown with profit. All the soil types are adapted to a greater diversification than is at present practiced, and the general lack of prosperity throughout the area is due primarily to this lack of diversification and the placing of too much dependence upon one crop.

Tobacco, practically the only crop marketed, is sold at Lynchburg or Farmville. All of that grown in the western half of the county and the greater part of that of the eastern half is hauled by wagons to Lynchburg, about 16 miles west of the area. The tobacco is sold at public auction by the farmer direct to the representatives of domestic and foreign manufacturers. The farmer pays a commission to the warehouse for the privilege of putting his tobacco upon the floor and of having an auctioneer. The tobacco goes to Germany, England, Austria, Italy, and Spain. The higher grades are used in the United States for plug wrappers.

There are no cities within the area. West Appomattox, the county seat and largest town, has a population of less than 200. All small stations along the railroads are shipping points for cross-ties, tan bark, lumber, and other forest products.

Good transportation facilities are afforded by the Norfolk and Western Railway, which crosses the southern half of the county. The Chesapeake and Ohio, which runs along the northern side of the James River, affords shipping points for the northern part of the area.

The public highways usually follow ridges, but often cross deep valleys on steep grades that might have been avoided if the roads had been laid out to follow the streams. During the summer and fall the roads usually wear down and pack, so that, barring occasional rocky stretches, they make good smooth-surfaced highways. In the midwinter and early spring months the highways usually become so sticky and cut up by travel that they are well-nigh impassable.

SOIL SURVEY OF LANCASTER COUNTY, SOUTH CAROLINA.

By **ALDERT S. ROOT** and **L. A. HURST.**

LOCATION AND BOUNDARIES OF THE AREA.

Lancaster County is situated in the northeastern part of the State of South Carolina, and comprises an area of 311,232 acres, or approximately 486 square miles. The county is irregular in shape, and is bounded on the north by the State line, on the east by Lynch Creek, on the west by the Catawba River, and on the south by Kershaw County. The Catawba River extends in a general north and south direction, and Lynch Creek flows slightly southeast. Lancaster, near the center of the county, with a population of 2,500, is the county seat and the largest town in the county. Kershaw and

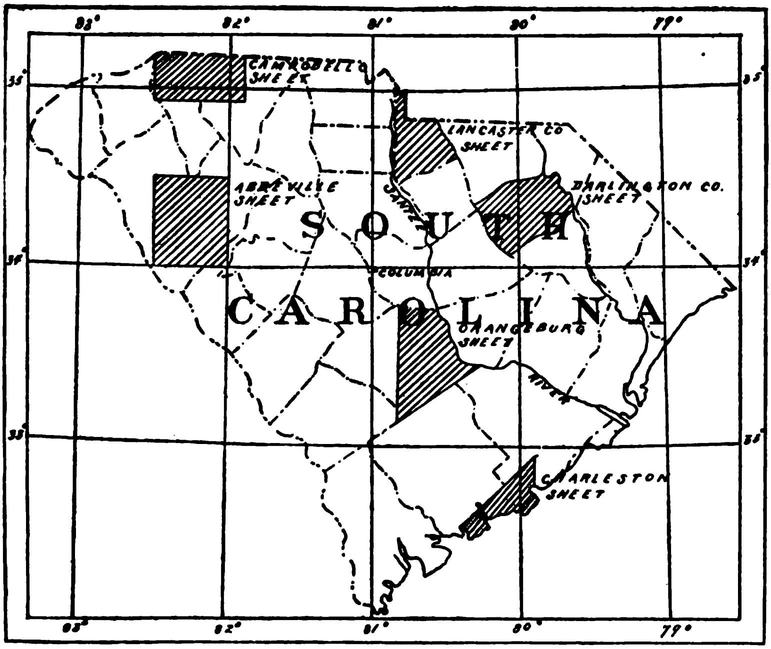

FIG. 5.—Sketch map showing location of the Lancaster County area, South Carolina.

Heath Spring are the only other towns, though there are several small villages. The population of the county is 24,311.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Originally Camden County included Camden, Lancaster, and Kershaw counties. By an act ratified March 12, 1785, the Camden district was divided into seven counties, to be known as Clarendon, Richland, Fairfield, Claremont, Lancaster, York, and Chester.

The first permanent settlers, who emigrated from Pennsylvania, were of Scotch-Irish descent. A few French were also among the early settlers. They met with such poor success in the cultivation of the crops to which they had been accustomed that they resorted to collecting and exporting the products of the great forests which surrounded them. In return for the necessaries of life they sent to the mother country tar, turpentine, resin, lumber, and skins. With the further settlement of the up country by the descendants of those who in 1670 established themselves on the seacoast of South Carolina the culture of wheat, barley, rye, corn, and tobacco became more successful, and the inhabitants of the Lancaster section, following the example of Joseph Kershaw, established flouring mills. In 1802 there were a number of these in operation in the county. About this time, however, the interest in cotton production became so great as to divert attention from every other crop, and the cereals lost ground until the low prices of cotton from 1840 to 1850 prepared the way for a greater diversity of agricultural industries. The small grain crop of 1850 exceeded in yield any produced up to that time. Since then the production of the cereals has again declined.

Indigo was conspicuous among the early crops. In 1745 the British Parliament placed a bounty on the production of indigo in British possessions, with the result that the crop reached a high development in South Carolina. Owing, however, to the cheaper production in India and elsewhere the industry was practically abandoned in the early part of the nineteenth century, though indigo was produced to a small extent until 1848.

CLIMATE.

No complete meteorological records were available for any places within the area, but the observations taken at Winthrop College, located at Rockhill, and at Winnsboro, situated, respectively, 28 miles northwest and 40 miles southwest of Lancaster, will suffice to show the approximate normal monthly and annual temperature and precipitation.

The following table was compiled from the Weather Bureau records for the two places named:

Normal monthly and annual temperature and precipitation.

Month.	Winthrop College.		Winnsboro.		Month.	Winthrop College.		Winnsboro.	
	Temperature.	Precipitation.	Temperature.	Precipitation.		Temperature.	Precipitation.	Temperature.	Precipitation.
	° *F.*	*Inches.*	° *F.*	*Inches.*		° *F.*	*Inches.*	° *F.*	*Inches.*
January	43.2	3.51	43.2	3.17	August	78.0	4.38	78.0	4.80
February	45.8	4.69	46.6	4.61	September	73.2	4.12	72.9	3.83
March	52.6	4.26	52.1	3.61	October	62.1	3.18	62.2	2.58
April	61.4	3.86	62.2	2.93	November	53.8	2.99	53.5	3.00
May	71.4	3.44	71.5	3.30	December	46.4	2.84	46.7	2.80
June	76.8	4.57	76.5	4.15	Year	61.9	46.56	62.0	43.78
July	79.0	5.22	78.9	5.00					

Light frosts are encountered in October and killing ones about the 1st of November. There is usually a slight snowfall in winter, but it remains on the ground only a short time. Sleet is more common. The prevailing winds are from the south and southwest.

There is some local difference in climatic conditions within the area. The sandy region in the extreme southeastern part of the county is somewhat warmer and drier than the country immediately north of it. It is also less subject to heavy dews and fogs.

The growing season lasts between seven and seven and a half months.

PHYSIOGRAPHY AND GEOLOGY.

Lancaster County represents an originally level plain which has undergone the erosive action of many streams to such an extent that its topographic features are now very marked, being made up of a succession of rolling hills and deep stream valleys. The divides have a tendency to descend rather abruptly to the narrow flood plains of the streams. In the extreme southeastern part of the county, around Kershaw and Heath Spring, the country assumes a more undulating and less rolling character, and it is here that the heavier types of soil—the Cecil series—give way to the lighter and more sandy soil—the Norfolk sand. As the large waterways are approached the surface becomes more broken and precipitous, and this rough unevenness characterizes the southwestern corner of the county.

The ridges in the county have a north and south trend, the main watershed being topped by the Rocky River road. This divide gives rise to two separate systems of drainage—that of Lynch Creek on the east and that of the Catawba River on the west. Both of these water courses receive the drainage of their many affluents at intervals of 3 or 4 miles. These latter streams flow generally east and west, and meander from their main direction but slightly, though extremely tortuous in detail. There is considerable undeveloped water power in these streams.

Two separate physiographic divisions, of different geological age, give rise to soils belonging to two series, as follows: The Cecil series, formed in situ from underlying rocks, and the Norfolk sand, derived from sedimentary deposits. By far the greater part of the county is made up of the former series, which occupies what is known as the Piedmont Plateau. In past geological ages this plateau represented the foothills of the Appalachian Range, but subsequently yielded to the erosive action of water and was worn down to form a gently undulating plain. Upon undergoing a later upheaval the stream courses began their work anew, and most of this section is represented at the present time by rolling topography. The soils of this plateau are derived from the weathering of granites, gneiss, diorite, talc schists, and other igneous and altered rocks which date far back in geological ages.

The Coastal Plain region, of much more recent date, encroaches upon the Piedmont Plateau in the southeastern part of the county, and is represented by a mantle of deep sand, composed mainly of rounded grains, which gives rise to the Norfolk sand.

Outcrops of the underlying granite make their appearance in many sections of the county, this being especially true on the soil type designated as Cecil gravelly loam. In the southwestern part of the county a very superior grade of fine-grained granite is being quarried and hauled to Heath Spring for shipment. Some mineral resources of the area are also being developed. There are two gold mines in active operation.

SOILS.

With the exception of the Norfolk sand, which is sedimentary, and the Meadow, an alluvial deposit, all of the types in the area surveyed are of residual origin. They are derived from the disintegration and decomposition of granites, talc schists, and other igneous and metamorphic rocks, and are characteristic soils of the Piedmont Plateau.

The actual and relative extent of each type of soil is shown in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Cecil clay	114,752	36.9	Cecil sandy loam	20,672	6.6
Cecil silt loam	74,048	23.8	Meadow	11,392	3.7
Norfolk sand	38,528	12.4	Total	311,232	
Cecil fine sandy loam	28,096	9.0			
Cecil gravelly loam	23,744	7.6			

CECIL CLAY.

The prevailing soil type in the Piedmont section, and the most valuable for general farming purposes, is the Cecil clay. It consists of a reddish-brown loam or clay loam to a depth of 4 to 6 inches, underlain by a sticky red clay, which becomes stiffer with depth. The underlying granite bed rock is usually encountered at from 20 to 60 feet, as shown by cuts and wells. Considerable organic matter is usually present in the upper 6 inches of soil, which in part accounts for its loamy character. Stony areas are common, but so deep and thorough has been the weathering that but a relatively small proportion of the land is of this character. A characteristic of the type is the occurrence in both soil and subsoil of quartz veins, which on account of their insoluble nature have resisted weathering. Where these outcrop on the surface the quartz fragments occur broadcast and in places are an impediment to cultivation. These areas, however, are limited in occurrence and extent.

The Cecil clay is found in very large bodies in the western and southeastern parts of the area and also occurs in lesser bodies in other parts of the county. It is found on the rolling hills and slopes in the northern part of the county, but to the southward more generally confines itself to the slopes and stream breaks. On account of its elevated position the type is well drained. It is derived principally by slow disintegration and decomposition from the older rocks, chiefly granites and gneiss, but also in less degree from diorite, porphyries, diabase, and other igneous and metamorphic rocks. These sometimes outcrop on the surface, a fact due in part to the greater durability of the rock itself, and in greater part to erosion, owing to its elevated position in relation to the contiguous slopes. These rocks are most frequently seen along stream courses.

The type comprises very little timbered land, but small groves of oak, hickory, and shortleaf pine are to be seen, usually on the more precipitous slopes. The soil has a tendency to wash and gully unless care is exercised in managing and cultivating it. This feature will be discussed in another part of the report.

Owing to its good drainage features, the type can withstand the effects of wet seasons to a marked degree, though it suffers from drought in the long dry seasons. This type is well adapted to cotton, and is cultivated almost exclusively to that crop, yielding from 200 to 250 pounds of lint per acre. Some corn is grown, and the yield is from 10 to 20 bushels per acre. The soil is also excellently adapted to grasses and small grain, though only a very small acreage is planted to these crops. Cowpeas are grown to a limited extent, but do not thrive on this type as well as on the more sandy soils.

The following table gives the results of mechanical analyses of fine earth of typical samples of the soil and subsoil of the Cecil clay:

Mechanical analyses of Cecil clay.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11834	3¼ miles W. of Lancaster.	Red loam, 0 to 4 inches...	1.4	3.1	3.4	22.8	26.8	24.8	18.4
11832	2¼ miles SW. of Vanwyck.	Red heavy loam, 0 to 4 inches.	2.1	10.3	9.3	23.4	14.7	11.7	28.1
11835	Subsoil of 11834......	Red stiff clay, 4 to 36 inches.	.6	1.1	1.8	10.5	9.6	37.2	39.3
11833	Subsoil of 11832......	Red stiff clay, 4 to 36 inches.	1.9	7.6	4.7	9.5	6.2	15.2	55.0

CECIL SANDY LOAM.

The Cecil sandy loam, on account of the demand for easily tillable land and the power of the soil to withstand drought, is considered equal to the Cecil clay in agricultural value. The soil, to a depth of from 6 to 15 inches, is a medium to fine sandy loam, brown or gray in color, and is underlain by a stiff, tenacious red or yellow clay, usually containing some sand. In its typical occurrence the subsoil is identical with that of the Cecil clay. Where the subsoil is a yellow clay, the sand in the soil is inclined to be finer, probably as a result of a difference in the rocks from which the red and the yellow clays were derived. In this phase the soil is closely related to the Cecil fine sandy loam, the one grading into the other. Quartz fragments occur in the Cecil sandy loam with the same frequency as in the Cecil clay. The line of demarcation between the two types is usually well defined.

The largest body of Cecil sandy loam is found in the extreme northwestern part of the county, while other considerable areas occur in the southern and other parts of the county. It occupies the undulating divides between stream courses, and occurs on level hilltops. The drainage is excellent.

The soil has been formed by the same process as the Cecil clay—by the slow weathering of granites and other similar rocks. Talcose schists play an important part in this soil's formation, giving rise to the yellow clay subsoil.

The Cecil sandy loam is adapted to cotton, corn, cowpeas, tobacco, and in a less degree to truck. It is exclusively farmed, however, to the first three crops mentioned. From 180 to 230 pounds of lint cotton, and from 8 to 15 bushels of corn are produced per acre. Peaches and other small deciduous fruits would do well on this type of soil.

The following table shows the texture of fine earth of both soil and subsoil of the Cecil sandy loam:

Mechanical analyses of Cecil sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11816	6 miles N. of Lancaster.	Brown sandy loam, 0 to 8 inches.	6.2	12.5	9.9	24.3	24.9	16.4	5.5
11818	3¼ miles W. of Heath Spring.	Brown sandy loam, 0 to 12 inches.	2.4	12.4	14.6	32.1	16.4	12.8	9.0
11819	Subsoil of 11818	Red clay, 12 to 36 inches	.5	7.2	8.7	15.4	6.8	21.4	40.0
11817	Subsoil of 11816	Red clay, 8 to 36 inches	2.6	6.2	4.7	10.2	9.1	22.9	43.9

CECIL GRAVELLY LOAM.

The soil of the Cecil gravelly loam to a depth of 7 inches usually consists of a brown sandy loam, carrying varying quantities of feldspathic or quartz gravel, which range in size from very small particles to fragments one-half inch in diameter. The subsoil is a heavy micaceous red loam or clay loam, in which considerable gravel also occurs. The mica imparts a characteristic greasy feel to the material. The subsoil is underlain at from 10 to 25 feet by granite in a state of decomposition. Outcrops of granite appear at frequent intervals, and where these occur the sandy loam, or surface soil, is deeper, as is also the case where the type occurs in swales and bottoms. Frequently the red subsoil is exposed at the surface, giving rise to patches of soil resembling the Cecil clay.

The characterizing feature of the type is its lack of tenacity in both soil and subsoil, as a result of which the land erodes and gullies in a serious manner. Many gulches from 20 to 30 feet deep were noticed, and much of the land comprising this type is beyond profitable reclamation. It occupies the high, broken uplands in the southwestern corner of the county and occurs also in a few smaller areas in the southwestern corner. The drainage is in all cases good.

This soil has been derived from the breaking down of granites, chiefly of a coarse-grained variety. Road cuts and washouts reveal the complete process of disintegration in its different stages. The type is in many ways related to the Cecil clay, and in its sandier phases to the Cecil sandy loam, but it represents a less complete weathering of the rocks, and this imparts a different character to the structure of the soil.

Twenty years ago this part of the county was very good agricultural land, but to-day the greater part of it is either abandoned or farmed by negroes, a result of the immense amount of washing and gullying which has taken place. Some of the type, however, is still very good farming land. The characteristic timber growth is oak, hickory, shortleaf pine, and some cedar.

For the first few years after cultivation excellent crop yields are obtained on the Cecil gravelly loam, but the productivity declines more rapidly than in other types of the Cecil series.

As long as a careful supervision is maintained over the soil, the crop yields compare favorably with those on the Cecil clay and the Cecil sandy loam. Cotton, corn, and cowpeas are the main crops. Cotton when properly cared for yields 230 pounds of lint and corn 8 to 15 bushels to the acre. Cowpeas do especially well. Grape growing on the precipitous hillsides and the cultivation of small fruits might be made profitable industries.

The results of mechanical analyses given in the following table show the texture of the fine earth of this soil type:

Mechanical analyses of Cecil gravelly loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11810	2¼ miles E. of Catawba River.	Brown sandy loam, 0 to 7 inches.	26.5	16.0	6.9	15.6	12.5	11.0	11.4
11812	1¼ miles S. of Heath Spring.	Brown sandy loam, 0 to 7 inches.	23.5	13.9	6.7	14.0	12.4	14.7	14.8
11811	Subsoil of 11810	Red loam, 7 to 36 inches	16.5	11.8	6.8	14.2	8.8	17.9	25.0
11813	Subsoil of 11812	Red heavy loam, 7 to 30 inches.	14.2	12.0	6.0	12.7	9.2	13.9	32.0

CECIL SILT LOAM.

The Cecil silt loam consists of a light-gray or ashy white silt loam. resting upon a yellow and slightly heavier silt loam at from 10 to 15 inches, which is underlain by a stiff yellow to red clay also containing silt in the upper few inches. This in turn gives way to the underlying talc schists. Where the weathering of these has not been deep, and they approach within 3 feet of the surface, the characteristic greasy feel of soapstone is imparted to the soil. Quartz fragments are conspicuous in places in both soil and subsoil, and frequently quartz veins are to be observed in the latter. These have little or no effect upon the agricultural value of the soil. Fine sand is often mixed with the soil, so that the dividing line between this soil type and the Cecil fine sandy loam is somewhat arbitrary, the two types closely resembling each other, and having the same origin and surface features.

A distinct phase of the Cecil silt loam is found in the northeastern part of the county, in the vicinity of Tradesville. Here the underlying talc schists come near the surface, often outcropping. Forming, as they do, a barrier to cultivation, much of the area occupied by this phase is unfit for agricultural purposes. When the talc slates are found within 8 or 10 inches of the surface, the soil carries large quantities of fragments which are also strewn thickly over the surface.

The Cecil silt loam, locally known as "white land," is second in extent in the area, forming by far the greater part of the northeastern part of the county, and occurring in more limited areas in other parts of the county. It occupies the undulating and well-drained uplands, and owes its origin to the disintegration of talcose schists and slates. Its characteristic timber growth has caused it to be known in some localities as "black-jack" land. Oak, hickory, persimmon, and pine also formed a part of the original timber, though most of the land is now cleared. As is the case with the other upland types, the Cecil silt loam is cultivated to cotton, corn, and to some extent to cowpeas. The yield of cotton is from one-third to three-fourths of a bale, and of corn from 8 to 15 bushels per acre, thus not differing from the yields on the types already described.

The following table gives the results of mechanical analyses of the fine earth of typical samples of this soil:

Mechanical analyses of Cecil silt loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11830	4 miles NE. of Lancaster.	Silty loam, 0 to 16 inches.	2.9	3.9	1.4	5.0	16.8	61.6	8.6
11828	½ mile S. of Lancaster.	Silty loam, 0 to 12 inches.	3.3	5.7	1.8	4.3	16.4	54.6	13.9
11826	2 miles N. of Primus.	Silty loam, 0 to 16 inches.	1.3	1.4	.7	2.9	9.4	68.4	15.7
11827	Subsoil of 11826	Yellow silty clay, 16 to 30 inches.	1.7	4.0	1.4	4.8	8.6	50.1	29.4
11831	Subsoil of 11830	Yellow silty clay, 16 to 36 inches.	1.3	2.8	.9	3.0	9.1	53.1	30.0
11829	Subsoil of 11828	Yellow silty clay, 12 to 36 inches.	1.0	2.1	.9	2.3	8.4	50.4	34.7

CECIL FINE SANDY LOAM.

The surface soil of the Cecil fine sandy loam consists of a light-gray fine sandy loam, grading into a pale-yellow fine sandy loam, slightly more compact. The surface soil extends to a depth of about 15 inches. Beneath this is found a yellow, or yellow mottled with red, subsoil, containing some sand for a few inches in its upper part. The whole is underlain at a depth greater than 3 feet by talc schists or slates, together with a small proportion of other altered rocks. Quartz fragments and gravel usually characterize the soil, and veins of the same material occur in the subsoil.

In structure the soil is an intermediate type between the Cecil sandy loam and the Cecil silt loam, though not necessarily so in occurrence. It grades into each of these, but so gradually that an arbitrary boundary separates them. Its largest distribution is in one continuous body, the central point of which is about 1 mile south of Drycreek. Much smaller areas are found elsewhere. The topographic position of the soil is similar to that of the Cecil sandy loam and Cecil silt loam—that is, on the undulating or level uplands. The drainage is almost perfect.

The Cecil fine sandy loam has been formed chiefly by the weathering of talcose schists and slates, though some other altered rocks enter into its formation. The timber growth consists of hickory, oak, and pine, with gums in the swales and depressions.

The two staple crops of the county, cotton and corn, are cultivated upon this type, as well as cowpeas, the last to a small extent. The average yields per acre are as follows: Cotton, about 200 pounds of lint; corn, from 8 to 15 bushels. The soil is also adapted to stone fruits and small grain. Alfalfa, it is thought, could be successfully grown upon it.

The texture of the fine earth of this type of soil is shown in the following table:

Mechanical analyses of Cecil fine sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11820	¼ mile S. of Drycreek.	Fine sandy loam, 0 to 15 inches.	0.9	4.7	4.2	29.7	33.7	21.7	5.1
11822	2¼ miles NW. of Taxahaw.	Light loam, 0 to 14 inches.	1.4	5.1	2.7	11.3	19.3	52.0	7.9
11823	Subsoil of 11822	Yellow silty clay, 14 to 36 inches.	1.4	3.5	1.6	6.4	13.2	48.4	25.1
11821	Subsoil of 11820	Yellow clay, 15 to 36 inches.	.7	3.1	2.0	11.7	20.4	27.3	34.3

NORFOLK SAND.

The Norfolk sand is a coarse to medium gray, incoherent sand, overlying a yellow sand, which grades at 36 inches or more into a yellow sandy clay. The sand particles are to a large degree rounded. In its typical occurrence the soil contains no quartz fragments and gravel, but where granite bowlders have pushed up through the mantle of sand the product of decomposed granite considerably modifies the soil, and in these cases gravel and angular quartz sand occur. This phase, however, is very limited in extent as compared with the distribution of the typical soil.

The areas of the Norfolk sand are confined to the extreme southeastern part of the county, in the vicinity of Heath Spring and Kershaw. The type occupies the level or gently undulating divides between stream courses and is remarkably well drained. It is sedimentary in origin, the sand having been laid down over the older formations. It occupies the extreme northern part of the great sand belt which stretches across the State from the Savannah River near Augusta to the intersection of the North Carolina line by the Pedee River. The characteristic timber growth is oak, hickory, and longleaf pine.

Owing to its loose, porous structure this soil type frequently suffers from the effects of drought. On this account, and because of the tendency of the soil to leach, it is important to render the soil more compact and more retentive of moisture by giving it heavier applications of manure or by growing cowpeas more extensively than is necessary on the other soil types.

The Norfolk sand is cultivated to cotton, corn, cowpeas, and melons. Wheat and oats are grown in small quantities. The average yields per acre, when the land is carefully handled, are as follows: About 200 pounds of lint cotton, 10 bushels of corn, from 6 to 8 bushels of wheat, and 10 bushels of oats. Cowpeas and melons do well. The soil is admirably adapted to light and early truck and small fruits. Unimproved land of this type can be bought for $3 an acre and improved land for from $5 to $15.

The results of mechanical analyses of the Norfolk sand are given in the table following.

Mechanical analyses of Norfolk sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11836	1 mile SE. of Taxahaw.	Gray coarse sand, 0 to 8 inches.	8.9	28.9	21.0	24.2	9.6	5.7	1.6
11838	2 miles N. of Kershaw.	Gray coarse sand, 0 to 9 inches.	12.8	33.6	19.5	18.8	6.7	6.4	2.2
11837	Subsoil of 11836	Yellow coarse sand, 8 to 36 inches.	13.2	30.7	19.0	22.3	7.2	5.4	1.9
11839	Subsoil of 11838	Yellow coarse sand, 9 to 36 inches.	12.2	32.1	19.9	20.1	6.2	7.6	1.9

MEADOW.

As is characteristic of nearly all recent fluvial deposits, the Meadow is more or less heterogeneous in its nature. In its typical phase it is a chocolate-brown or reddish fine sandy loam, becoming somewhat heavier with depth. It sometimes develops into a loam or clay loam at a depth of 15 or 18 inches, while the color becomes darker and the soil more micaceous.

As the type is subject to overflow, the water, laden with sediments, has stood in the swales and depressions, and upon evaporation has left a heavier soil than that surrounding it. These places, however, cover only a small acreage.

The type is subject to variations along the minor stream courses. It occurs as a narrow strip along the Catawba River and the larger creeks, rarely exceeding one-eighth of a mile in width. It is subject to overflow once every three or four years. It consists of the finer particles which have been washed down from the adjacent hillsides and reworked by the streams with the sediment of the latter. This alluvium is very productive.

The Meadow is devoted to the production of corn and small quantities of sorghum. Corn averages from 20 to 30 bushels per acre. These "bottom lands" are greatly sought after, notwithstanding the risk of frequently losing a crop. Some portions command as much as $50 an acre.

WASHING AND GULLYING.

The Cecil clay, Cecil sandy loam, and, most markedly, the Cecil gravelly loam are the soil types most liable to damage from washing and gullying. As to the first two of these, this condition may be attributed to the rolling topography and fineness and compactness of the soil constituents, whereby the water from heavy rains is not allowed to enter the soil except for a few inches, but runs off in rills, carrying with it the fine soil particles in suspension. These rills start little gullies, which, left to themselves, increase in size until they seriously affect the value of the land. In the case of the Cecil gravelly loam its high position on the uplands and the marked lack of tenacity in both soil and subsoil account for the serious erosion and gullying which takes place in this type.

With the clay soils especial attention should be given to the tillage of the land. Deep plowing and thorough cultivation, whereby the compact subsoil is rendered more friable and its texture more open, will largely prevent washing, as it tends to minimize surface drainage and to facilitate underdrainage. Terracing and contour cultivation should be more generally practiced, especially where the Cecil gravelly loam occurs. Putting areas in sod will help to prevent soils which have begun to gully from suffering further damage. Mulches, bushes, etc., placed in the gullies will also check the washing to a great extent.

Although much of the region occupied by the Cecil gravelly loam is beyond reclamation, a great deal could be done to prevent further denudations in areas that are still available as farming land. The incorporation with the soil of more organic matter, by which addition its structure would become more tenacious, would be decidedly beneficial.

AGRICULTURAL METHODS.

Cotton and corn are the principal crops in Lancaster County. The planting of cotton begins about the middle of April and is completed by the middle of May. The seed used is of the short-staple variety. The land is plowed from 4 to 6 inches deep, and laid off with the shovel plow, the fertilizer being drilled in and bedded with a turning plow. The rows are set from 3 to 3½ feet apart. The usual fertilizer is cotton seed, sometimes composted with phosphates and stable manure, and applied at the rate of 25 bushels of seed and 200 pounds of acid phosphate to the acre. About 2 or 2½ bushels of seed are required to plant 1 acre, the seed being usually sown by hand. When a stand is perfected the thinning process follows, the stalks being left about 6 inches apart. About four plowings suffice to keep the soil in good condition. Cotton picking begins the last of August, and harvesting is completed by Christmas. No effort is made to select the seed from the best-developed plants, the farmers not seeming to appreciate the fact that they can do much in this way to make the crop profitable.

The value of the cowpea in enriching the soil is partially recognized, but more attention should be given this crop by the majority of the farmers. A common practice is to plant cowpeas in the corn at the last cultivation. The fodder is gathered by hand from the stalks and the corn harvested, and later the cowpeas are cut, cured, and stored for forage. The cornstalks are left in the field until the following spring, when they are gathered and burned. A few of the best farmers in the county recognize the economy of gathering the stalks and utilizing them for forage.

Fallowing is nowhere practiced, and the benefit derived from the rotation of crops is unappreciated. Cotton and corn occasionally follow each other. On the Norfolk sand crop rotation is even more necessary than on the heavier soils, and the following excellent three-year system has given very satisfactory results to the few leading farmers who have practiced it: First year, oats and cowpeas; second year, corn; and third year, cotton. The oats, maturing in June, are followed by the cowpeas, which are harvested in September and October, and the roots turned under. Stable manure, which has been composted with pine straw, is spread along with the oats. Not much stable manure is used, however, as stock raising plays no part in the agricultural interests of the county. Commercial fertilizers are extensively used, the Twelfth Census showing $70,380 expended for this purpose in the county in the year 1899.

No subsoiling is carried on, though in other localities the results from that practice have been beneficial. Plowing to the same depth each year explains in part why the heavier types of soil are rendered so compact, and why, as a consequence, they suffer so materially from drought. Such soils require deeper plowing to secure more thorough aeration and to aid in the conservation of moisture. An application of lime would tend to improve the structure of the Cecil clay by rendering the particles less cohesive. It is claimed that the expense attendant upon fall plowing does not warrant its being carried on, since the soils, in consequence of the winter rains, are about as compact in the spring as they ordinarily would be without fall plowing.

AGRICULTURAL CONDITIONS.

Although the soils and climatic conditions are identical with those found in other highly developed sections of the Piedmont Plateau, agriculture in Lancaster County is backward and is unquestionably retarded by the system of farming practiced. The large acreage devoted to certain crops is out of proportion to the amount of labor employed and cultivation given. A large number of farms are rented to those who have no personal interest in them, aside from the direct returns obtained thereform. The Twelfth Census shows the total area in farms to be 271,316 acres, of which 119,117 acres are improved. Only about 26 per cent of the farms are operated by the owners.

While most of the landowners who work their own farms are progressive and prosperous, the tenants as a class are not in a very enviable condition. This is evidenced by the lack of comforts and conveniences which characterizes their homes. This condition is in great part the result of the lien system which prevails to a large extent within the area. As a rule, the tenants have little or no capital to carry on their work. The result is that in order to support themselves and their families while the crop is being cultivated, the merchant or landowner is allowed to take a mortgage on the crop or part of it, and it frequently happens that the value of one-third, three-fourths, or even of the whole crop is consumed before it is harvested, leaving nothing with which to commence the next year's work. This system is very unfortunate. As a natural consequence, the maintenance of soil productivity is a minor consideration, and statistics show that the lands thus utilized on most of the tenanted farms are steadily deteriorating in productiveness.

Several different systems of tenure prevail in the area, the share system being the most popular. In this case the landowner furnishes the stock, implements, and half the fertilizers, and the tenant furnishes the labor; an equal division of the crops being made. In some instances a specific rental is preferred, whereby a certain amount of cotton is taken by the landowner for the rent of each "one-horse" farm—in other words, from one to two bales for as much land as can be cultivated with a single horse, which is about 30 acres.

The average farm contains about 90 acres, but this average is considerably lowered when the small tracts tenanted by the negroes are taken into consideration. Many plantations comprise 1,000 acres or more. The farm values range from $2 or $3 an acre in the more inaccessible parts of the county to $25 or more near the towns, the average for improved land for the county at large being something over $14 an acre.

The farmers of Lancaster County have no troublesome labor question to deal with as yet. Field hands, usually colored, are available during all seasons of the year. They receive while working by the month from $8 to $15, and 50 cents a day when employed for shorter periods. During the cotton-picking season hands are paid according to the amount picked, the price ranging from 40 to 50 cents per hundred pounds.

The interests of the farmers are largely absorbed in the cultivation of cotton. According to the Twelfth Census, 49,646 acres were devoted to this purpose in the county. Corn is the next most extensive crop, the acreage for 1899, the latest available exact figures, being 33,059. Oats, wheat, peas, and truck, in the order named, are cultivated to a less degree. Small patches of sorghum are seen on many of the farms, the sirup made being used for domestic purposes. In the southeastern part of the county the sandier soils around Heath Spring and Kershaw are eminently adapted to melons, which are grown to a considerable extent. None are shipped, however, the home market receiving the greater part of the supply. There are a few orchards, but very little is done toward keeping them in good condition. There is every reason to believe that the growing of fruits, such as peaches, pears, and plums, would be attended with great success. For these crops the sandier soils would prove better than the heavier types.

It is rather singular that so little attention is given to the production of vegetables for home consumption. There are to be found on almost every farm suitable soils for the cultivation of garden truck, which would help the farmer not only to reduce his living expenses to a minimum, but would furnish a greater diversity of diet for himself and his family, yet there is a marked lack of interest in the production of these necessaries.

Since stock raising is not followed in this county, and adequate manurial elements can not be supplied from this source, the legume must be chiefly relied upon as an economical soil renovator. The farmers are gradually realizing the beneficial results of such crops, and a more extensive acreage is being devoted to their cultivation. It can not be pointed out too clearly how invaluable such crops are in almost all sections of the South, not only in supplying plant food to the soil, but also in improving its physical structure. In addition to the cowpea, alfalfa has been grown with success in other localities on the Cecil sandy loam, and the Cecil fine sandy loam would be equally well adapted to it.

There is little encouragement, however, for a wider introduction of crops adapted to the soils of Lancaster County. Cotton will likely continue to be the all-important crop. A home market is afforded by the large mill situated at Lancaster, which consumes the greater part of the cotton grown in the county, Chester, Rockhill, and Camden receiving the surplus.

Fairly good transportation is afforded by the three railroads which enter the area. The Southern Railroad runs through the county in a northwest and southeast direction, passing through the town of Lancaster; the Seaboard Air Line intersects the panhandle in the extreme northwestern part, touching the villages of Vanwyck and Osceola; while the Lancaster and Chester Railroad offers a means of traffic between the towns of Lancaster and Chester. The eastern half of the county is somewhat at a disadvantage as regards transportation, since no railroads traverse that section.

The public highways are not very satisfactory. Several years ago they were worked by convict labor, but the farmers are now required to do this work, and the roads are not so good as formerly.

SOIL SURVEY OF THE ORANGEBURG AREA, SOUTH CAROLINA.[a]

By FRANK BENNETT and A. M. GRIFFEN.

LOCATION AND BOUNDARIES OF THE AREA.

Orangeburg County lies in the south-central part of South Carolina, and has an extent of 1,345 square miles, being the second county in point of area in the State. The area mapped takes in all of that part of the county lying east of a line running north and south through Orangeburg, and covers 454,080 acres, or about 710 square miles—a little over half of the entire county. The Congaree and Santee rivers form the northern and eastern boundaries of the area, respectively, while the Edisto River forms a small portion of the boundary on the southwest corner. Berkeley and Dorchester counties adjoin it on the south.

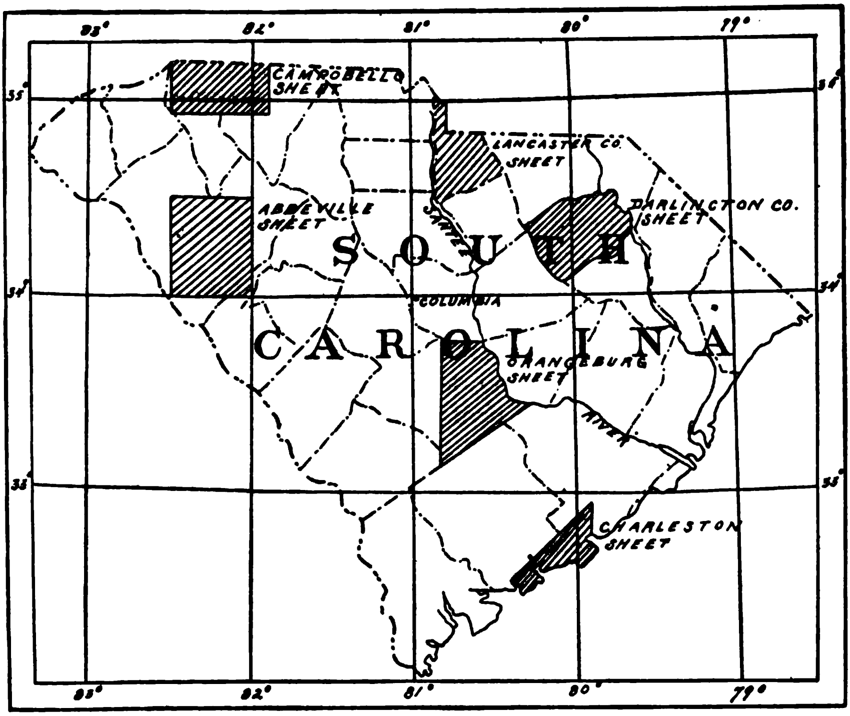

FIG. 6.—Sketch map showing location of the Orangeburg area, South Carolina.

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[a] This survey was begun in the season of 1903 by Messrs. Mangum and Griffen.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Shortly after 1700 a few white settlements had been made in the territory now included within Orangeburg County. In the year 1735 and in succeeding years a large number of Swiss and German immigrants came into the newly opened territory and founded a town upon the Edisto River, which they called Orangeburg, in honor of William, Prince of Orange. Subsequently this name was applied to a large section of surrounding country, of which the present county was a part. These early settlers were not adventurers, but tillers of the soil, seeking homes in a new country. A large number of the present white population are their direct descendants and possess their characteristic thrift and industry.

The first crops tried in this region were adapted to a colder climate, and hence proved almost a failure. The great pine forest that ranged on every side seemed to afford a better means of livelihood than could be obtained through a direct tilling of the soil, so the people brought in breadstuffs and clothing, and exported large quantities of tar, turpentine, rosin, staves, shingles, lumber, beef, pork, and hides. The forest furnished excellent grazing, and several local names, such as "Cowpens," "Middlepen," "Cattle Creek," and "Cow Castle Swamp," indicate the early centers or suggest the importance of the live-stock industry.

Indigo was first grown about 1740, and after the bounty offered for its production by the English Government in 1750 it became an important export. East India competition and the war with the mother country caused a rapid decline in its culture, and, except for a brief period prior to the civil war, it has not been grown since. Considerable quantities of corn, wheat, and oats were raised up to about 1850. From this date up to 1865 very few oats were grown, on account of the ravages of the rust, but shortly after this the red rust-proof varieties were introduced, and in recent years a considerable acreage is sown to wheat and oats, especially in the "Red Hill" region.

For a period of ten years after the civil war much rice was planted along the stream bottoms and in swampy areas, and a yield of from 20 to 50 bushels per acre was obtained. Competition, however, with the large irrigated fields nearer the coast could not long be maintained, and the cultivation of this crop, except for home consumption, has been abandoned. Pea-vine hay has been grown during the last few years and has become an important factor in the agriculture of this section. It gives a good yield on almost every soil and is fed to all kinds of stock with good results. The quantity of sugar cane grown has not changed perceptibly during a long period of years. It grows well both on the uplands and lowlands, and enough is produced to supply the home market with sirup. The turpentine industry was started on a large scale soon after the civil war and continued profitable until about 1885. Cotton was not grown to any extent until 1802. By 1850 it had become the principal crop of the area, which position it has since held.

The first sawmill was established in 1850, and was run by water, this being the power used for all the mills until about 1875. The larger part of the timber up to this date was floated down the streams to the coast. The first timber cut was pine, and it was not until about 1880 that the cypress and hardwoods of the bottom lands were cut to any extent. Besides the sawmills, there are five cotton-seed oil mills within the limits of the area surveyed. The first of these was built at Orangeburg in 1885.

CLIMATE.

The climate of the area is generally very mild and many plants adapted to a semitropical climate are found growing here. As a general rule the crops suffer more from an excess of rain than from drought, this being especially true in the southern part of the area, where the country is flat. The average rainfall for each month is a little less than 3 inches.

The first killing frost in the fall occurs usually between November 5 and 20, and the last in the spring about the middle of March.

The data in the following table, taken from the records of the Weather Bureau stations at St. Matthews, St. George, and Blackville, show the normal monthly and annual temperature and precipitation. St. Matthews lies within the area surveyed, while St. George and Blackville are to the south, near the line of Orangeburg County.

The crops in the southern part of the area are usually about ten days in advance of those in the northern part.

Normal monthly and annual temperature and precipitation.

Month.	St. Matthews.		St. George.		Blackville.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	° F.	*Inches.*	*° F.*	*Inches.*	*° F.*	*Inches.*
January	46.9	2.73	46.4	3.15	45.9	3.50
February	46.4	4.76	46.9	4.17	45.9	4.99
March	55.3	3.19	56.8	3.29	56.6	3.57
April	64.0	3.62	63.6	3.20	64.1	3.60
May	72.9	3.80	72.8	3.14	73.2	3.81
June	79.0	5.30	78.2	5.48	80.1	5.25
July	80.4	6.58	80.4	6.04	81.4	5.73
August	80.4	6.32	79.7	6.40	80.3	5.99
September	75.1	3.59	74.9	5.25	75.2	3.98
October	64.5	2.46	64.1	2.41	64.2	3.22
November	55.8	2.19	55.8	2.46	55.7	2.08
December	47.1	2.93	47.4	3.46	46.9	3.61
Year	64.0	46.97	63.9	48.45	64.1	49.33

PHYSIOGRAPHY AND GEOLOGY.

Orangeburg County is situated in the Atlantic Coastal Plain. In its northeastern part is found a part of the "red hill" region of the State, but this soon gives way to the "upper pine belt," which continues southward through the county.

Physiographically the area may be divided into two main parts, the larger consisting of the flat lowlands and the smaller of the rolling country to the northward. The town of Orangeburg, with an elevation of 259 feet, lies nearly upon the boundary line, and from this place the line of division extends in a northeast direction. The lowlands are occupied principally by two types of soil, the Norfolk sandy loam and Portsmouth sandy loam.

Theu pland country assumes its rolling character slowly and attains its greatest elevation a little to the south of St. Matthews. As a rule the subsoil of this part of the area consists of a red clay, though directly to the north of Orangeburg the Norfolk sandy loam—a type with a yellow subsoil—is typically developed. The region to the east and north of St. Matthews is a spur of what is known in the State as the "red hill" region. The prevailing soil type is the Orangeburg sandy loam, which is considered the most productive in the area.

To the northwest of St. Matthews a portion of the "sand hill" region of the State is included within the area. This extends in a broad plateau and terminates abruptly in steep bluffs along the Congaree River. The sand is coarse and unproductive.

The drainage of the northern and eastern parts of the area is by smaller creeks directly into the Congaree and Santee rivers. A divide extends from Orangeburg to St. Matthews nearly along the lines of the Southern Railway. To the westward of this divide the streams flow into the Edisto River, while those to the eastward find outlet through the Four Hole and Half Way swamps. A number of the streams have sufficient fall to be utilized in the running of grist and saw mills. The Santee and Congaree rivers are navigable to small steamers during the greater part of the year. The rivers are bordered by a strip of lowland which averages about half a mile in width.

In the northern part of the area well water is obtained at a depth of from 30 to 70 feet, while springs are common in the hillsides. In the lowlands the water level is usually from 6 to 15 feet below the surface. Artesian wells have been sunk at Bowman and Branchville, and a good supply of water obtained at a depth of from 150 to 200 feet.

The materials forming the surface of the area are all of comparatively recent geologic age, and consist of red and yellow sandy clays and sands belonging to the Lafayette.

In general the whole area is covered by a gray quartz sand underlain by clay. The depth of the sand varies from a few inches to many feet, as will be seen from the description of the soil types.

Small deposits of quartz and quartzite gravel occur in many parts of the yellow clays, and at a depth of several feet layers of a white kaolitic clay are often found. In many cases both the red and yellow clays present a gray mottled appearance. In others the yellow clay is underlain a foot or two below the surface by a stratum of the red. A few small outcrops of a Neocene shell limestone are also found. These, with a small quantity of a coarse ferruginous sandstone near the Congaree River, constitute the only rock outcrops in the area. Near Bowman an 8-foot stratum of lignite has been found, and it is likely that this may cover a considerable area.

SOILS.

The table below gives the names of the several soil types found in the Orangeburg area, together with the area of each type and the percentage which each is of the total area surveyed.

As will be seen in the table, the soils have been divided between nine types, including Swamp. All but one of these—the Norfolk fine sandy loam—have been mapped in other areas.

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Portsmouth sandy loam	131,904	29.0	Norfolk fine sandy loam	4,480	1.0
Norfolk sandy loam	126,592	27.9	Congaree clay	2,944	.6
Norfolk sand	86,080	19.0	Sandhill	256	.1
Orangeburg sand	45,312	10.0	Total	454,080	
Swamp	40,448	8.9			
Orangeburg sandy loam	16,064	3.5			

NORFOLK SANDY LOAM.

The soil of the Norfolk sandy loam is a gray or dark-gray sand or sandy loam, ranging in depth from 9 to 18 inches. The subsoil is a yellow clay or yellow sandy clay. As the top soil is darker than that of any of the other cultivated upland types, it is locally referred to as "black lands."

A large part of this soil type occupies broad and level areas and is usually well drained, though shallow ditches are often necessary to carry off the surplus water after rains. A few areas upon which water once stood during the greater part of the year have been drained by the open-ditch method, and are at present producing excellent crops. East of Four Hole Swamp the areas are broad and rather uniform in texture, though often dotted with small areas of Portsmouth sandy loam. West of Four Hole Swamp the type occurs as knolls and flat ridges in the Portsmouth sandy loam. Small areas are numerous in the vicinity of Bowman. They are at a lower elevation, and as a rule the sand is coarser and the depth to the clay subsoil greater than in the main type in the larger areas. The greater part of the Norfolk sandy loam occurs in the southern part of the survey, with its northern limit nearly on a line drawn from Orangeburg to Cameron. In general, this line serves to separate the high from the low country. A peculiarity of the soil in this part of the survey is its tendency to compact, a characteristic probably dependent upon the structure or relative proportions and arrangement of the different soil particles. This feature, however, is not difficult to overcome, as good drainage, together with applications of manure and thorough cultivation, will put the soil in good physical condition.

There is another phase of the Norfolk sandy loam where the soil is lighter and the subsoil less tenacious. Such an area lies within a strip 5 miles in width and 14 miles in length, running north from Orangeburg and extending about 2 miles north of St. Matthews, and smaller bodies occur elsewhere. Both the soil and subsoil contain iron concretions and pebbles, the quantity increasing as the subsoil is approached. The sand becomes coarser in the lower part of the soil section, and the presence of this material and of the concretions gives the subsoil considerable porosity and lessens its tenacity. Frequently the iron concretions in the subsoil have decomposed, giving rise to spots of red-colored soil, and in some small areas the concretions are so plentiful as to give the soil the characteristic of a gravelly loam. This phase of the type in the main occupies gently rolling uplands, and the drainage is usually good. In such locations the best bright tobacco grown in Orangeburg County is produced. In fact, the Norfolk sandy loam as a whole is the best soil in the area for the production of bright tobacco, and is so recognized by the farmers. It produces from 1,000 to 1,200 pounds per acre.

In value and crop yields this type of soil ranks next to the Orangeburg sandy loam. It possesses one advantage over the latter, since, because of its topography, it is not subject to erosion; but on the other hand, during a wet season, crops sometimes suffer from an excess of moisture. It is suited to most of the crops grown in the area. The average yield of cotton is about one-half bale per acre, of corn from 15 to 30 bushels, and of pea-vine hay from 1,500 pounds to 2 tons. Certain portions of the type are fairly well suited to truck crops. Pecan and peach trees have a thrifty growth. The Le Conte pear grows vigorously, but often suffers from blight.

Nearly all of the Norfolk sandy loam is under cultivation. Where not cultivated the main timber growth is longleaf pine, with a scattering of hardwood species. The price of the Norfolk sandy loam ranges from $15 to $30 an acre, depending upon its location and the improvements.

The following table gives the results of mechanical analyses of typical samples of this soil:

Mechanical analyses of Norfolk sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
9555	1½ miles S. of Jamison.	Gray coarse sand, 0 to 15 inches.	9.4	21.7	9.3	29.1	19.0	6.8	4.8
9559	Orangeburg	Gray sand, 0 to 13 inches.	2.9	11.9	13.7	42.5	17.7	6.8	5.2
10911	3 miles SE. of Orangeburg.	Gray sandy loam, 0 to 18 inches.	4.2	17.3	14.3	29.3	21.6	7.8	5.5
10909	1 mile NW. of Elloree.	Gray sandy loam, 0 to 9 inches.	11.5	22.4	14.2	24.4	13.7	7.3	6.5
9557	Stilton	Gray coarse sand, 0 to 10 inches.	4.6	20.1	14.1	32.5	14.1	6.2	8.6
9560	Subsoil of 9559	Yellow sandy clay, 13 to 36 inches.	3.4	11.8	10.8	26.6	14.1	7.9	24.9
10912	Subsoil of 10911	Yellow sandy clay, 18 to 36 inches.	4.2	13.0	10.3	20.5	19.1	7.1	25.8
9558	Subsoil of 9557	Yellow sandy clay, 10 to 36 inches.	3.7	13.3	10.9	23.4	12.8	7.6	28.7
9556	Subsoil of 9555	Yellow sticky sandy clay, 15 to 36 inches.	7.7	13.2	6.9	17.6	10.9	6.2	36.8
10910	Subsoil of 10909	Yellow clay, 9 to 36 inches.	7.2	13.8	7.9	13.1	7.9	7.1	43.4

PORTSMOUTH SANDY LOAM.

The first 6 inches of the Portsmouth sandy loam is a heavy dark gray or almost black sandy loam. The sand is distributed in all four grades, with a preponderance, as shown by the mechanical analyses, in the fine sand grade. Considerable organic matter is mingled with the surface soil. The second 6 inches is a light gray and often almost a white sandy loam, containing less organic matter than the top soil. The subsoil is a drab or yellowish sandy clay, mottled with iron stains, though frequently in spots it is simply a white sand.

The Portsmouth sandy loam occupies low, flat areas, and in many places is swampy and wet. It would have been more nearly correct to have classified such places as "Swamp," but owing to their frequent occurrence in small areas it was found impracticable to separate them. Water stands upon them during a great part of the year, and they become entirely dry only after a drought. The soil of this phase is a black silt loam, rich in organic matter, containing for a depth of from 10 to 15 inches little, if any, sand. The subsoil is practically of the same character as that of the main type.

The Portsmouth sandy loam is locally known as the "bay and pine flats," the lower-lying portions being covered with a growth of bay, gum, and cypress, with a thick undergrowth, while the more elevated portions have a growth of longleaf and shortleaf pine.

In many places, especially in the southern part of the area, this type is spotted with knolls of Norfolk sandy loam, giving the surface of the country an uneven character. These knolls are elevated from 2 to 6 feet above the adjacent soil. Where the type occurs in broad and uniform areas the surface is very level. Practically all of this soil is uncultivated. Its value heretofore has been determined almost entirely by its timber growth. While the Portsmouth sandy loam is of very little agricultural value at the present time, it is one of the most important soil types of the area, since it occupies such an extensive area of undeveloped land. It is likely that within a few years a large part of it will be brought under cultivation. However, before this can be accomplished it will be necessary to introduce an extensive system of drainage. Thus far only small spots of a few acres in extent have been ditched, while there are many thousands of acres needing reclamation.

Many of the farmers consider this soil one of the most productive types of the area. They have drawn their conclusions from results obtained by draining small depressions in the other types. When this type occurs in broad flats, the soil extends only to a depth of from 4 to 6 inches, and were these flats drained it is likely they would not prove as productive as might be expected, though they would produce comparatively good yields.

In the case of nearly every large area a drainage outlet could be found within a few miles of its center. Where the type has a sandy subsoil some trouble might be experienced by the caving in of canal banks.

The Portsmouth sandy loam occurs almost entirely south of a line running east from Orangeburg. The largest areas are found in the vicinity of Fifty-eight and a short distance northeast of Rowesville.

This soil is an intermediate type between the Norfolk sandy loam and Swamp, and when it is drained both the soil and subsoil will in time assume more the character of the former. This change will be brought about by a loss of organic matter from the soil, due to cultivation, and by the oxidization of the iron in the subsoil, a process which will be hastened by its freedom from excessive moisture and exposure to air.

The Portsmouth sandy loam furnishes excellent grazing, but is used very little for such purpose. Where it has been drained cotton has occasionally been planted, but usually suffers from rust. The use of kainit as a fertilizer has been found to prevent this to a great extent. Most of the rice grown in the area is upon this soil. It is planted in rows and cultivated, and the fields are never more than a few acres in extent. No attempt has been made at irrigation, and it is doubtful whether this method would prove profitable, though where the type occurs near the Edisto River water could be readily secured. The lands would have to be cleared and both drainage and irrigation canals constructed. It can not be considered a typical rice soil, since it contains so much sand that it would require heavy flooding to maintain the proper conditions. The expense of preparing the type for extensive rice culture would probably be too great to permit competition with the black clay prairies of the Southwest, which are by nature so much better adapted to this industry.

The following table gives the results of mechanical analyses of samples of this soil:

Mechanical analyses of Portsmouth sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
10782	4 miles NE. of Branchville.	Heavy sand, 0 to 6 inches.	5.1	20.3	14.2	33.9	14.2	6.5	5.5
10916	1¼ miles W. of Elloree.	Heavy loam, 0 to 8 inches.	4.8	13.0	7.4	14.7	11.6	20.5	27.9
10783	Subsoil of 10782	Gray sandy clay, 6 to 36 inches.	6.9	18.4	11.6	22.6	11.8	6.6	21.6
10917	Subsoil of 10916	Gray clay, 8 to 36 inches..	3.3	9.6	5.5	9.8	7.6	23.1	40.5

ORANGEBURG SAND.

The Orangeburg sand and the Orangeburg sandy loam are closely related, the main difference being in the depth of sand covering the clay subsoil. As mapped in this area, the Orangeburg sand consists of a dark-gray sand or light sandy loam, 8 to 30 inches deep, underlain by a stiff, red sandy clay. The presence of organic matter in the first 6 inches of soil makes it darker than that farther from the surface, which usually has a yellowish tinge. The subsoil often contains small pebbles and reddish iron concretions, and in some cases these may have worked their way up into the soil. The typical depth of the sandy loam is about 15 inches. The sand varies from medium to coarse in texture and consists of rounded grains. Where the soil has not been properly cultivated and such crops planted as add no vegetable matter, the soil, except in land just cleared, shows very little difference in color at different depths.

The Orangeburg sand occupies no broad areas, but is well distributed over the entire rolling portion of the survey. In the Orangeburg sandy loam region to the east and northeast of St. Matthews it is usually found occupying rolling upland and ridges between stream courses. It is also found on hillsides along some of the stream courses. In the less rolling part of the area it occurs in connection with the Norfolk sandy loam, and often a single field will show several alternations between these two types. The upland position of this soil generally insures good drainage.

The Orangeburg sand is considered a good type of land for general farming. It was not found practicable in mapping it to distinguish between those lands having only 15 inches of sandy loam and those having 30 inches, and the value of the type has a wide range, decreasing as the depth of the sand increases. The texture of the sand also affects the crop yields. In certain local spots the sandy loam becomes finer and more compact, and there it is better able to hold moisture and fertilizers.

The average crop yields, where the soil is typical, are as follows: Cotton, one-half bale; corn, 12 to 16 bushels, and oats, 20 to 25 bushels per acre. Cotton and corn are the two principal crops. Sweet potatoes, peanuts, and tobacco are sometimes grown. The land sells for from $15 to $30 an acre. The timber growth consists of longleaf pine and hardwoods.

The following table gives the results of mechanical analyses of typical samples of this soil:

Mechanical analyses of Orangeburg sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
9575	1¼ miles SE. of St. Matthews.	Gray sand, 0 to 17 inches..	4.0	11.8	9.6	34.0	30.4	5.9	3.8
9573	2 miles N. of St. Matthews.	Gray sand, 0 to 15 inches..	5.8	17.2	6.4	23.6	36.0	5.8	4.7
9571	2¼ miles SW. of Jamison.	Gray coarse sand, 0 to 14 inches.	7.0	19.8	6.9	24.9	27.5	7.0	6.8
9576	Subsoil of 9575	Red sandy clay, 17 to 36 inches.	2.1	6.4	5.4	21.5	24.8	13.1	26.7
9574	Subsoil of 9573	Red sandy clay, 15 to 36 inches.	3.9	14.8	5.4	18.2	23.8	6.0	28.4
9572	Subsoil of 9571	Red sandy clay, 14 to 36 inches.	4.3	12.9	4.9	12.4	19.9	7.1	38.4

ORANGEBURG SANDY LOAM.

The soil of the Orangeburg sandy loam consists of a dark-gray sand or light sandy loam from 0 to 8 inches deep, with an average depth of 5 inches. The sand is medium to coarse in texture and the grains rounded. When the soil is shallow it often has a reddish tinge, due to mixture with the subsoil. The subsoil to a depth of 3 feet or more is a stiff, dark-red sandy clay, through which are scattered a few small pebbles and iron concretions. Bands of these may frequently be seen in road cuts or gullies.

The Orangeburg sandy loam is the principal soil of a large tract to the east and northeast of St. Matthews, known locally as the "red hill" region. This area is large and uniform, but smaller areas are found associated with many of the other upland types. These smaller areas usually occupy steep hillsides or are near stream courses where the sand has been washed off, leaving the clay either exposed or covered with but a few inches of sandy loam. The topography of the tract first referred to is moderately rolling, and the drainage is good. This type is the best cotton land in the county, as well as being the best for all general farming crops except tobacco. Crops generally do well upon it either in a wet or dry year. In a dry season the clay subsoil holds sufficient moisture to carry over the crop, and in a wet season the rolling character of the surface prevents the soil from becoming water-logged, as it often does in the lower country. The sandy surface soil also allows the type to be worked in a minimum lapse of time after rains. Clay having a covering of from 4 to 5 inches of the lighter material is considered the most valuable for crop production.

As a rule terracing on this type is not necessary, but in certain cases erosive action has removed a large part of the sand from the hillsides and left bare clay fields streaked with gullies resembling those of the Cecil clay regions found in the Piedmont. It takes years again to fit these fields for cultivation, and a little careful terracing at the right time would have saved much loss.

Cotton on this type will average from one-half to three-fourths of a bale per acre, and when well fertilized and properly cultivated certain extensive tracts will produce a bale per acre. Corn produces from 20 to 30 bushels per acre on much of the land, but will not average over 15 bushels. Oats will average 20 to 25 bushels per acre, and in a good year will produce as high as 40 bushels. As a rule it pays to fertilize these lands heavily. Farms in good state of cultivation sell for $25 to $40 per acre.

The characteristic growth of timber on this type is shortleaf pine, dogwood, hickory, and several varieties of oak, with a sprinkling of longleaf pine. This combination is not found in any of the other types. The second growth of pine is usually of the shortleaf variety.

The following table gives the results of mechanical analyses of typical samples of this type of soil:

Mechanical analyses of Orangeburg sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
9569	4 miles N. of Orangeburg.	Gray coarse sand, 0 to 6 inches.	6.9	18.0	8.9	25.8	27.0	8.1	5.4
9567	3 miles NW. of Cameron.	Gray sand, 0 to 6 inches..	3.0	8.2	4.2	29.5	41.6	7.4	6.0
9565	¼ mile SW. of Singletons.	Gray sand, 0 to 5 inches..	7.1	11.0	5.6	30.3	31.4	7.7	6.2
9566	Subsoil of 9565	Red sandy clay, 5 to 36 inches.	4.3	9.3	4.2	19.8	23.5	7.4	31.2
9568	Subsoil of 9567	Red sandy clay, 6 to 36 inches.	2.6	5.2	2.9	16.4	25.5	10.8	36.6
9570	Subsoil of 9569	Red sandy clay, 6 to 36 inches.	4.4	10.9	5.5	15.3	16.5	5.5	41.8

CONGAREE CLAY.

The soil of the Congaree clay consists of 3 feet or more of light-brown or chocolate-colored clay, containing some very fine sand. From 8 to 36 inches the material is a little lighter in color than the top soil, and occasionally a thin seam of very fine sand is found. The terraces contain a little more sand than the low-lying areas, and often small particles of mica, brought down from the Piedmont, are found scattered through the soil. The soil in the low-lying areas consists of about 10 inches of heavy brown clay, underlain by a brownish yellow subsoil of practically the same material. This phase of the type, which is inclosed between the river terrace and bluffs, forms a kind of basin, and water stands upon it during a wet season or after an inundation. Where it has been ditched or where there is some small stream to give an outlet into the river, it drains very rapidly, but there are many small sloughs or ponds where the water remains a large part of the year. These places were at one time covered by a dense growth of cypress, most of which now has been cut. The timber growth of the remainder of the type is principally gum, hickory, cottonwood, and sycamore, with some pine and cypress. The second growth is largely sycamore and cottonwood.

The larger part of the cultivated area of this soil lies in a narrow strip along the river. The overflows, which occur quite frequently and seem to have been more numerous of late years, have caused general farming to be abandoned because of the uncertainty of a crop. A large part of the cleared area of this soil type is covered by a rank growth of Bermuda grass, to which the soil seems well adapted and at present it could be utilized most profitably for stock raising. Two crops of hay are always secured and often three are cut in a season. Corn sometimes yields from 40 to 50 bushels per acre and oats from 50 to 60 bushels.

The following table gives the results of mechanical analyses of this soil:

Mechanical analyses of Congaree clay.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*Pc. t.*	*P. ct.*
9579	½ mile E. of Beaver Creek.	Brown loam, 0 to 14 inches.	0.1	0.2	0.3	5.4	17.3	51.5	25.2
9581	1 mile E. of Southern Rwy. bridge.	Brown clay, 0 to 12 inches.	.1	.3	.4	3.0	11.1	48.9	36.2
9577	1 mile E. of Southern Rwy. bridge.	Brown clay, 0 to 8 inches.	.1	.3	.5	2.0	2.2	50.7	44.2
9582	Subsoil of 9581	Light-brown clay, 12 to 36 inches.	.0	.1	.3	3.4	10.7	49.6	35.7
9580	Subsoil of 9579	Brown clay, 14 to 36 inches.	.1	.4	.1	1.9	8.9	51.8	36.4
9578	Subsoil of 9577	Brown clay, 8 to 36 inches.	.0	.6	1.2	4.5	3.9	47.3	42.7

NORFOLK FINE SANDY LOAM.

The Norfolk fine sandy loam consists of about 5 inches of fine gray loamy sand, underlain by about 10 inches of yellow fine sand containing very little organic matter, which rests upon a subsoil of yellow sandy clay, the sand in both soil and subsoil being of the finer grades. Occasionally small spots are found where the yellow sand which underlies the first 6 inches of soil extends to a depth of 3 feet, becoming less loamy as the depth increases until at a depth of 30 inches it is almost a pure sand.

The Norfolk fine sandy loam occupies a relatively small proportion of the survey. It occurs in a few comparatively broad and uniform areas about 5 miles north of Bowman. The surface is level, but the drainage is good. Almost all of the type is under cultivation and very little of it has any timber growth.

This type is closely related to the Norfolk sandy loam, the main differences being in the texture of the sand and in the agricultural value. The sand of the Norfolk fine sandy loam is finer than the

Norfolk sandy loam and the crop yields are lower. It is said to be better adapted to corn than to cotton, yielding from 15 to 20 bushels of corn and from one-fourth to one-half bale of cotton per acre.

The following table gives the results of mechanical analyses of typical samples of this soil:

Mechanical analyses of Norfolk fine sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
10852	5¼ miles N. of Bowman.	Fine sandy loam, 0 to 16 inches.	1.3	5.7	6.1	60.5	15.1	7.7	3.6
10854	8¼ miles NE. of Bowman.	Fine sandy loam, 0 to 18 inches.	1.5	8.3	8.8	56.8	12.0	7.7	4.9
10853	Subsoil of 10852	Yellow sandy clay, 16 to 36 inches.	2.9	6.1	5.1	47.5	10.9	6.6	20.9
10855	Subsoil of 10854	Yellow sandy clay, 18 to 36 inches.	1.2	6.2	6.4	42.1	9.2	9.4	25.5

NORFOLK SAND.

Norfolk sand consists of 3 feet or more of sand, the greater proportion being nearly uniformly distributed in the coarse, medium, and fine grades. The first 6 inches of the surface soil is a gray, loamy sand, a little darker in color than the subsoil, which is of a reddish-brown or yellowish color. This variation in the color of the subsoil is influenced by the topography. The type occupies broad table-lands and comparatively steep rolling areas. Where it occupies the lowest of the table-lands it usually occurs in spots or small areas, and here the subsoil is yellowish, while in the more elevated and rolling portions it is generally reddish brown, though the yellow subsoil is also often encountered in such positions.

The Norfolk sand is also found in all parts of the area as a washed deposit along stream courses. This phase is always yellowish in color and usually quite coarse in texture, although when surrounded by the Norfolk sandy loam the texture may vary from medium to fine. In the southern part of the area, in addition to the deposits found along the streams, there are usually ridges of Norfolk sand surrounding certain large swamplike depressions in the Portsmouth sandy loam, locally known as "bays." These ridges are from 6 to 15 feet above the adjacent soil, and are composed of yellow sand.

A series of sandy hills, varying from 2 to 4 miles in width, border the bottoms along the Congaree and Santee rivers and often approach close to the rivers themselves, forming a series of bluffs which are locally known as the "River Hills." Among these hills, which become less rolling as the southern part of the area is approached, are numerous V-shaped valleys that have been eroded by the streams.

It is very seldom that the red clay, which underlies by far the greater proportion of this type, is exposed on the slopes, but occasionally it comes near enough to the surface—that is, within 3 feet—to give rise to small areas of Orangeburg sand. These areas are usually found in the cultivated fields, which are subject to greater erosion than the timbered areas. And it is through the washing away of the overlying sand that this difference in soil type arises.

The small areas of Norfolk sand which occur in the south and southwestern parts of the survey are underlain by a yellow clay at a comparatively slight depth. Along the "River Hills" it may be 25 or even 60 feet to the red clay.

From the description of the "River Hills" it would seem as if they should be classed as Sandhill, but the sand is not so coarse as that of the true Sandhill and does not possess its characteristic looseness.

On account of the loose and leachy character of the Norfolk sand it is of little value for general farming. It is, however, well adapted to fruit and truck crops and might be utilized advantageously for these products in the present area as it has been in other sections of the Atlantic seaboard.

The application of commercial fertilizers on the Norfolk sand has not proved very profitable. In a rainy season very little effect is seen even from a heavy application, as the materials go into solution and leach out before the plant is ready to take them up. When commercial fertilizer is used, it should be applied in small quantities at different periods of the growing season. In preparing this soil for cotton the fertilizers should be put on top of the ground in the middle of the old rows instead of making a new furrow, as is usually done. The undisturbed soil is more closely packed and has a greater tendency to hold moisture. What this soil needs most, however, is organic matter, and the best fertilizer is barnyard manure. The timber growth on the Norfolk sand is longleaf pine and scrub oak. There is less of the Norfolk sand cultivated than of any of the other types in the area except the Portsmouth sandy loam. The crop yields are so small that very little profit, if any, is realized. This type of soil may be bought for from $2 to $5 per acre.

The following table gives the results of mechanical analyses of typical samples of this soil:

Mechanical analyses of Norfolk sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11180	1 mile E. of Elloree..	Coarse sand, 0 to 8 inches.	5.2	24.7	20.5	30.7	9.5	5.4	3.6
10913	2¼ miles SE. of Branchville.	Dark-gray coarse sand, 0 to 6 inches.	8.8	33.1	17.1	21.2	9.7	4.0	5.8
10915	Subsoil of 11180......	Yellow coarse sand, 8 to 36 inches.	4.9	20.7	18.5	34.8	10.2	5.6	5.2
10914	Subsoil of 10913......	Yellow coarse sand, 6 to 36 inches.	12.5	29.6	14.4	18.7	9.8	5.1	10.4

SWAMP.

The term Swamp is applied to a soil that is too low and too wet to be of any agricultural value, except for rice growing. This type occurs as low, flat, and poorly drained areas along stream courses, the largest areas being found along the Santee River and Four Hole Swamp. It borders all of the smaller streams, and here many areas were too narrow to be represented on a map of the scale used. The soils grouped as Swamp have not been classified according to texture. They may be sand, clay, or silt, but, from the little examination possible, the material is usually a mixture of sand and yellow or gray clay.

The principal growth on the Swamp consists of water-loving grasses and trees, and only occasionally is it cultivated. A few fields, 1 or 2 acres in extent, are used for rice, and this at present is its sole agricultural use. With proper drainage more of this type could be brought under cultivation, but this will not be done for many years to come, as there is much land of other types that can be put in cultivable condition at less cost.

SANDHILL.

In the extreme southern part of the area a peculiar topographic feature is found, locally known as "Sandy Island." It consists of a mound rising to an elevation of from 10 to 12 feet above the adjacent soil and having an extent of a few hundred acres. It is surrounded by the Portsmouth sandy loam and Swamp. The soil is of a uniformly coarse textured sand to a depth of 3 feet or more. In the first 6 inches the color is slightly darkened by the presence of a very small proportion of organic matter; below this the material is approximately white. This one area is the only true Sandhill soil found in this survey. It has a slightly rolling topography and possesses some of the characteristics of a sand dune, and only here and there occurs any vegetation, generally a small bush, scrub oak, or pine.

The following table gives the results of mechanical analyses of soil and subsoil of this type:

Mechanical analyses of Sandhill.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10920	8¼ miles SE. of Branchville.	Light-gray sand, 0 to 5 inches.	5.4	42.0	24.8	24.7	1.6	0.7	0.6
10921	Subsoil of 10920	White sand, 5 to 36 inches.	11.8	37.0	27.8	21.4	1.2	.4	.1

AGRICULTURAL CONDITIONS.

The greater proportion of the more productive soil of Orangeburg County is at present under cultivation. Considerable areas once under cultivation have been abandoned for virgin soil, but there yet remain thousands of acres of soil as fertile as any under cultivation, as well as large areas covered by forests of pine, cypress, and hardwood, less desirable for crops now generally grown.

At one time, when virgin lands were cheap and plentiful, the farmers could afford to cultivate one field until the soil was exhausted, then abandon it and clear up new land for cultivation. Now that the country has become more thickly settled and land values have increased it is no longer practicable to follow the loose, wasteful methods of yesterday. As a result the farming practices are gradually improving and a more economical and intelligent system is being introduced. More attention is being given to the use of fertilizers and the rotation of crops in the effort to maintain the productivity of the soils. It is the general opinion that where careful attention has been given to these matters much larger crop yields are being realized by the farmers.

The farms vary in size from 50 to several thousand acres. The larger farms are gradually being cut up into smaller ones, and at present the average size of farm is probably between 75 and 100 acres. Probably 75 per cent of the area in small farms is under cultivation, while in many of the larger ones not more than 50 per cent is cultivated.

Considering only the more productive types of soil, land values have easily doubled during the last ten years. At the beginning of this period prices ranged from $8 to $20 an acre. Good land now brings $15 to $40 an acre, and some of the best improved farms near the towns are held as high as $50 an acre. In the northern, eastern, and southern parts of the area, where the broad tracts of the Norfolk sand and the Portsmouth sandy loam lie, wild land can still be bought for from $2 to $5 an acre.

The leading crops are produced largely under the share system, though in some cases land is rented for a definite quantity of cotton, usually from 30 to 40 pounds lint cotton per acre, depending upon the productivity of the soil. Very little, if any, land is rented for cash. Under the share system the landowner furnishes the land, work animals, implements, fertilizers, and seed; in other words, everything that is necessary to grow a crop except the labor. The tenant cultivates and harvests the crop, and in return for his year's labor receives one-half the products, usually cotton and corn. In allotting the land on shares, 30 acres is allowed to each horse. From 20 to 25 acres of this is commonly planted to cotton and the remaining 5 or 10 acres to corn. In most cases where the land is cultivated on the share system, the landowner furnishes the tenant supplies during the year, for which certain interest is charged and a mortgage or lien taken on the tenant's half of the crop as security.

Many of the tenants who pay a certain amount of cotton per acre are furnished their yearly supplies by the merchants of the near-by towns. In this case the landowner receives his rent first and the merchant is paid out of the remainder of the crop, on which he holds a mortgage security.

Many of the farmers cultivate their land with labor hired either by the year, month, or day. The wages range from $6 to $7 a month and board, or $9 to $10 without board. In addition to this many farmers allow the hands hired by the year or month 2 or 3 acres of land for their own use. The hoeing of the cotton is usually contracted for by the acre, the price ranging from 35 to 45 cents. The rate paid for picking cotton is from 40 to 50 cents a hundred pounds of seed cotton. The cotton-picking time is considered by the negroes as their happiest and most prosperous season, as the end of each week finds them with money in their pockets. A good hand can pick from 200 to 225 pounds a day. All the negro children, half-grown and upward, who are unable to do other farm work, are found in the cotton fields during the picking season. They can each pick from 50 to 100 pounds a day. Often a single family picks from 500 to 800 pounds a day.

The owners of the larger plantations gin their own cotton and occasionally do a little ginning for neighboring farmers, for which $1 a bale is the usual charge. The cotton-oil mills, which are situated in the towns and have the latest improved machinery, gin cotton for 50 or 75 cents a bale.

The low price of cotton in 1897 and for several years prior thereto compelled the farmers of the county to look for some other money crop, along with cotton. In this endeavor tobacco was introduced into the area. The farmers, who were entirely inexperienced, employed experienced tobacco men to instruct them in the methods of growing and curing the tobacco. These instructors were employed on a salary, one man having general supervision over several farms. The first year between 250 and 300 acres were planted in the county, and in general the results were satisfactory. Enough profit was made to pay the salaries of the tobacco experts employed and to cover the expense of building proper barns in addition to the expenses ordinarily incident to cultivation.

An advance in the price of cotton soon after the introduction of tobacco caused a decrease in tobacco acreage, though each year since its introduction it has been planted to some extent. Some of the growers realize handsome profits, while others have failed, owing, for the most part, to poor management. The exceptionally high price of cotton the present year (1904) and the low price of tobacco will likely cause a further reduction in the acreage of tobacco, though the county has been benefited more by the introduction of the industry than many now realize. Whereas cotton formed the sole money crop prior to the introduction of tobacco, the farmers over a large part of the county can now change from one crop to the other according as the prices are high or low, or better still, they may plant both and thus guard against loss due to sudden fall in the price of one or the other product.

The highest grades of bright tobacco are produced more uniformly on the rolling and well-drained Norfolk sandy loam, a type which has been found specially adapted to this crop in most of the other bright-tobacco districts.

Orangeburg County ranks first in the State in the production of cotton. According to the last census the cotton crop of the county in 1899 was 62,309 bales, the average yield being one-half bale per acre.

Very little attention has been given to the raising of live stock, though there are lands that could be utilized more profitably for this purpose than in any other way. There are a few farmers who raise enough meat and corn for home use. A great many, however, do not produce enough of these products to carry them through the winter, while others purchase almost all their home supplies.

The number of live stock in the area has not materially changed in the last ten years, though some of the townships bordering the rivers and those including large areas of the Portsmouth sandy loam show a slight increase in the number of cattle and there has been a little more attention given to cattle raising in these areas in recent years.

Bermuda grass covers a large proportion of the bottom lands and is used for hay and also for grazing purposes. This grass makes a vigorous growth and is often cut three times during a season. There are areas of the Norfolk sand bordering the Santee and Congaree rivers that support a good growth of Japan clover and these would furnish fair grazing. There are also broad areas of the Portsmouth sandy loam that offer excellent grazing, but it is very seldom that a pasture is found on either of these types. In all there are many thousand acres of land now lying idle that would furnish good grazing during six or seven months and in some places, where there is a good growth of cane, during the entire year.

Pea-vine hay can be used to a large extent for winter feed, besides the hay cut from the wild grasses. The importance of cowpeas as a forage crop is becoming more widely recognized. After grain is harvested the stubble fields are sown broadcast in peas, which are cut for hay early in the fall, making from 1 to 2 tons per acre. It is usually worth in the early winter from $8 to $10 a ton and in late winter from $12 to $18 a ton, thus giving a profit equally as great and often greater than the preceding grain crop and at the same time increasing the productiveness of the soil. It would seem from such advantages that the raising of cattle could be largely extended and made a very profitable industry.

Although some of the soils, especially the Norfolk sand and the Norfolk sandy loam, are well adapted to the production of fruit and truck, only small quantities of asparagus, green peas, strawberries, and peaches are grown and shipped to the northern markets. Some extension in the fruit and truck industries is taking place, however, and there seems no good reason why these interests should not become of considerable importance. Some plantings of asparagus made in recent years have proved particularly profitable.

In general the farming class of Orangeburg County is prosperous, though the conditions vary considerably in different parts of the county and on different soil types. The most valuable and best kept plantations are usually found in the Norfolk sandy loam, the Orangeburg sand, and the Orangeburg sandy loam. In the central, southern, and southeastern parts of the county, which are low and flat, a large percentage of the farming is done by negroes and the progress has been slower.

The greater part of the timber has been cut, though there still remain some pine forests and a few good tracts of cypress. The cypress grows in swampy places where it is very difficult to get it out. The most of the sawmills in operation are in the southern part of the county, the timber being cut from the Portsmouth sandy loam.

The area is traversed by the Southern and Atlantic Coast Line railroads. There is also a narrow gauge road about 12 miles long which connects the towns of Branchville and Bowman. The Southern and the Atlantic Coast Line intersect at Orangeburg, the county seat, which is situated in the western part of the survey, and is the only town in the area that has any railroad competition. The Southern Railway crosses the extreme southern part of the area through Branchville, and also extends north almost parallel to the western edge of the map to Orangeburg, from which place it turns eastward and crosses the northern corner of the area. The Atlantic Coast Line crosses the area a little north of a central point on the map, and also has a branch line running through the central eastern portion.

The nearest cities to the area are Charleston and Columbia, S. C., and Augusta, Ga. The Southern Railway furnishes direct transportation to all these, while the Atlantic Coast Line reaches the latter. These cities are within a few hours' run of Orangeburg. Most of the farmers live within a reasonable distance of a railroad, the most distant point being about 10 miles. Nearly all of the cotton is shipped to Charleston, S. C., Savannah, Ga., and Wilmington, N. C.

The county roads in the area, as a general rule, are rather poor, being usually deep with sand where they cross areas of the Norfolk sand and the Norfolk sandy loam. The roads are now being improved by convict labor. The soils of the area are either largely sand or clay, which when mixed make excellent road material at a small cost.

SOIL SURVEY OF THE CHARLESTON AREA, SOUTH CAROLINA.

By **F. E. BONSTEEL** and **E. P. CARR.**

LOCATION AND BOUNDARIES OF THE AREA.

The Charleston area, South Carolina, is included between the meridians 79° 50′ and 80° 20′ west longitude, and the parallels 32° 30′ and 32° 45′ north latitude, and lies mostly within Charleston County, a small portion lying within Colleton County. It is bounded on the east by the Cooper River and Charleston Harbor channel, on the south by the Atlantic Ocean, on the west by South Edisto River, and on the north by a line which is an extension of the Bees Ferry road, being nearly parallel with the coast and extending from the confluence of the South Edisto and Dawho rivers to Cooper River. The area varies from 12 to 14 miles in width and from 30 to 36 miles in length, comprising about 430 square miles, of which about 352 square miles is land surface, and extending from Charleston Neck southward along the coast, including the sea islands.

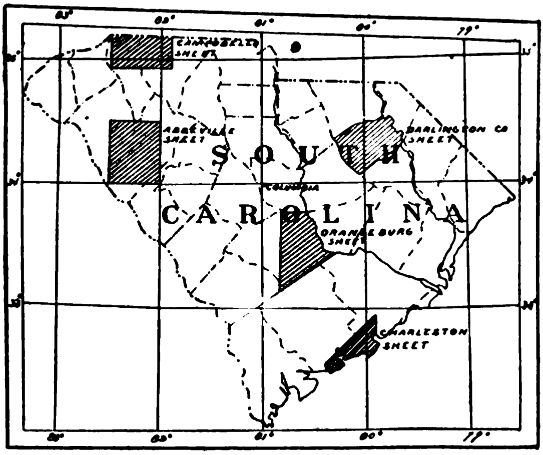

Fig. 7.—Sketch map showing location of the Charleston area, South Carolina.

The area is traversed in every direction by many salt-water channels, most of which are navigable for vessels of medium draft. Charleston, with a population of 55,000, about 25,000 of whom are whites, is the commercial center of the area, and its only town. Charleston has a fine harbor for vessels of deep draft and offers exceptional port facilities. Its importance as a port has not been recognized, and the volume of shipping is not commensurate with the natural advantages. There are few whites in the remainder of the area, the colored population being very largely in excess.

The base map used in the soil survey was constructed by plane-table traverse by the party in the field. The coast and some of the stream boundaries were adapted from Chart No. 154 of the United States Coast and Geodetic Survey.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The settlement of Charleston and the neighboring coast area can be definitely traced to a band of colonists sent out from England in 1670 by the Lords Proprietor, to whom Charles I had granted the territory known as "Carolina."

These colonists first touched at Port Royal, but fear of the hostile Spaniards impelled them to seek a settlement farther north, and in April, 1670, they landed at Albemarle Point, on the Ashley River, just opposite the present site of Charleston, naming their settlement Charles Town.

During the following year the present site of Charleston was selected and laid out, and the settlement was transferred to the new location. The number of colonists at this time was about 200. Those who came later were chiefly political or religious refugees. Following the revocation of the edict of Nantes, in 1685, a great many French Hugenots came to the colony.

Commercial relations with the English markets were established soon after the settlement had been made, and among the articles exported were potatoes, indian corn, and tobacco together with hides, ship timber, and naval stores. Lumbering became a leading industry in later years.

Rice was introduced in 1691, with seed from Madagascar, and proved very successful. The rice was first grown on inland swamps, where its cultivation continued for 75 years. By this time the superiority of the reclaimed tidal swamps along the rivers in the upper portions of the area, due to better control of irrigation and drainage, had been discovered, and the culture was transferred accordingly.

The preparation of the rice for market in the early days was very laborious, entailing the use of a flail and a pine-stump mortar and pestle for separating the grain and cleaning the seed. The first water mill for milling rice was erected in 1787 and a steam mill was established in 1817. The milling of rice continues to be a leading industry of Charleston, but the main areas of rice soil lie just outside the limits of the present survey.

The Carolina colony was affected by the widespread early colonial interest in silk culture, but although the culture involved no special agricultural difficulties the venture was not an economic success, not paying so well as rice and cotton.

The cultivation of indigo was introduced in 1741, and was encouraged by a parliamentary bounty of 6d. per pound. After the Revolution the industry became unprofitable without the bounty, and was superseded by the more profitable culture of cotton.

Cotton was found to do well from the first, and was exported as early as 1784. The Sea Island cotton was first grown in this area in 1790, from Georgia seed. The plant had originated, however, in the West Indies. Until 1828 its culture was largely a process of experiment and development, and great care was necessary in order to insure success. In 1842 a production of 20,000 bags was reported. The industry was prostrated by the civil war, and at one time all the seed from which the present product of Sea Island cotton has been derived was contained in an ordinary envelope.[a] More recently a variety has been secured which yields about one-third more lint in proportion to seed cotton than the earlier varieties.

Tobacco has been continuously and successfully grown in the area, though some difficulty has been experienced with its curing.

The growing of early truck for Northern markets is a development of recent years, but has now become a flourishing industry. The labor problem resulting from the civil war has been worked out to a satisfactory solution. The laboring class is composed entirely of negroes.

The population of the area, including Charleston, may be estimated at 70,000, of which a considerable majority, especially in the rural districts, is colored.

CLIMATE.

The following table gives the normal monthly and annual temperature and rainfall for the Charleston station of the Weather Bureau, located in the eastern part of the area surveyed, and for the Summerville station, about 15 miles outside the northern boundary. It will be noticed that the rainfall is ample and well distributed. The temperature is mild in winter, and the heat of the summer months is tempered by the fresh sea breezes.

Damaging frosts are rare throughout the area in the growing season and snow seldom falls. The climate is favorable to the production of early truck, which matures at such a season as to follow the bulk of the Florida shipments and to precede the earliest from the Norfolk, Va., region.

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[a] Charleston Yearbook.

Normal monthly and annual temperature and precipitation.

Month.	Charleston.		Summerville.		Month.	Charleston.		Summerville.	
	Temperature.	Precipitation.	Temperature.	Precipitation.		Temperature.	Precipitation.	Temperature.	Precipitation.
	° F.	*Inches.*	*° F.*	*Inches.*		*° F.*	*Inches.*	*° F.*	*Inches.*
January	50.0	4.01	48.0	3.78	August	80.5	7.62	80.0	9.44
February	52.8	3.82	48.5	4.81	September	76.0	6.59	75.0	3.14
March	56.7	3.94	57.1	2.69	October	66.7	4.18	66.0	5.86
April	64.6	3.58	62.6	5.05	November	57.6	3.00	56.1	3.47
May	72.4	4.02	71.4	3.22	December	51.5	3.24	48.8	4.02
June	79.1	5.65	76.7	7.87	Year	65.8	56.74	64.1	50.16
July	81.8	7.59	79.2	5.70					

PHYSIOGRAPHY AND GEOLOGY.

The portion of Charleston County covered by the present survey comprises a strip of sea-border territory lying along the eastern edge of the South Atlantic Coastal Plain. The topography of the area is uniformly flat and low lying, the long, level stretches which reach to the sea front being only occasionally relieved by gentle ridges or hummocks a few feet in height, so that the difference in altitude within the area does not exceed 30 to 40 feet. The district differs, however, from many portions of the Atlantic border in that it is highly diversified by a system of waterways which forms within the area four considerable islands, and which gives it a distinct physiographic character. Various explanations have been given of the formation of these sea islands, but in view of their location at the mouths of the Cooper, Ashley and Edisto rivers, it seems safest to regard them as delta deposits.

This view is supported by the fact that these islands have a recognizable delta or triangular shape, and by the further fact that the margins on nearly all parts of the islands are higher than the inland areas, and indicate influences of river deposition. These margins were probably first formed in the nature of a bar by the combined action of ocean and river currents. This bar then served not only to deflect the course of the rivers southward, where further deposition would likewise be made, but also to form between the sand bar and river shore an eddy, in whose quieter currents the river could then lay down its finer deposits. Continued deposition would in time cause the eddy or lagoon to become a mud flat or salt marsh, which would then be further built up by vegetation, and drift sands from the sand bars. There have doubtless been other agencies to aid this work, such as a moderate emergence of the land, and the cutting in of channels by the sea in times of storm. But that these islands constitute a delta plain, and were built up largely by river and tidal deposits, seems to be clear.

Besides the main rivers—Cooper, Ashley, and Edisto—there are numerous so-called rivers and creeks which are properly brackish tideways, serving to connect the different rivers or channels. The complexity of this water system serves not only to secure ready steamboat transportation to many parts of the area, but it has also a distinct agricultural value in preventing the injury of the truck and cotton crops by frost. The close proximity of the sea as affecting the climatic and crop conditions must not be overlooked, as it is a general experience that the best quality of Sea Island cotton grown in the area is produced on the lands that lie near the sea front.

Along the many tidal channels are found extensive stretches of salt marsh in varying stages of emergence. Most of these are covered with water at high tide, but some patches here and there have been left dry by changes in the channels, while others are in a half emerged state, in which they have been modified by washings from the shores or are gradually changed into fresh-water swamps. Wherever such marsh lands are situated far enough inland to allow of fresh water irrigation and proper drainage, they have been reclaimed and made into highly productive rice lands.

The sandy soils of the area follow generally the course of the slight ridges above referred to, except in the immediate neighborhood of the sea, where the soils are uniformly sandy. These ridges or hummocks of sand sometimes show clearly the course of an older beach line, and generally are derived from former sand bars or coarser current deposits. On the sea islands these ridges of sand are found more frequently near the margins of the islands; not, however, on the sheer front of the water channels, because here the sands have been somewhat eroded, and the soils are, as a rule, of heavier texture and used mostly for truck. But just behind these eroded and lower lying soils there is generally a well-defined rise of sand, following, and indeed often making, the outline of the island, just as it doubtless constituted the backbone of the island in its first formation. These higher ridges or sandy rises are used almost entirely for cotton.

As we pass farther inland the lands again become depressed and poorly drained, and it is in these inland areas that the large fresh-water swamps are found. These swamps rarely owe their origin to springs, but almost invariably to the uniformly high water table. These black, mucky swamp lands are thus generally confined by the higher lying sand areas, the waters of which seep out into them and are held as in an inland basin. They are much affected by conditions of season and rainfall.

In its geology the Charleston area consists of superficial strata of sand, mud, and clay, with a depth varying up to 60 feet, which stretch some 10 miles inland and thin out above tide water. These strata are marine depositions of Pleistocene or possibly later origin, the sediments being laid down upon the sea floor by the varying currents of a shallow sea and subsquently exposed by a slight elevation of the coastal region The delta plain formed by the sea islands is of more recent origin, the materials being largely these same emerged Pleistocene deposits reworked by the rivers.

These surface strata are underlain to a depth of from 600 to 700 feet by the Ashley and Cooper river marl beds of Eocene age. These marl beds were formed, as was the Eocene sea floor, from oyster and coral shells, just as similar beds are now forming farther off the coast. The upper portions of these marl beds now consist of nodules which represent fragments broken from the underlying beds and worn into nodular form by the mechanical action of the waters during the following uplift.

These marl beds originally contained some 60 per cent of carbonate of lime with only 2 to 4 per cent of phosphate of lime, but the upper beds of the waterworn fragments now contain 50 to 60 per cent of phosphate of lime and only 5 to 10 per cent of lime carbonate. The proportions of carbonate and phosphate of lime have thus been almost inverted, and these beds are now extensively mined for phosphatic fertilizers. The cause of this conversion of the carbonate of lime into phosphate has been a matter of considerable discussion, and need not be entered into here.

These phosphate beds outcrop here and there along the stream channels in the area, but for the most part are deeply covered and are profitably mined only to a depth of 20 feet.

SOILS.

Six distinct types of soil were recognized and mapped in this area. Only three of the types are extensively tilled, the remaining types being largely unfit for cultivation in their present condition.

The following table shows the total area and relative extent of each type mapped:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Galveston clay	77,312	34.3	Galveston fine sand	5,696	2.5
Norfolk fine sand	61,504	27.3	Norfolk sand	1,088	.5
Norfolk fine sandy loam	47,680	21.2	Total	225,344	
Portsmouth fine sandy loam	32,064	14.2			

NORFOLK FINE SAND.

The soil of the Norfolk fine sand is a light-brown or yellowish fine sand of great uniformity, varying from 6 to 18 inches in depth, and having an average depth of 12 inches. The surface is naturally very loose and incoherent, but becomes slightly loamy on cultivation. The particles composing it are so fine as to have a very flourlike feel, yet the type is decidedly a sand. Very little silt, clay, or coarse sand enters into its composition.

The subsoil to more than 36 inches is a pale yellow to bright orange or sometimes gray fine sand, loose and incoherent, and in the uncultivated areas differing but slightly from the soil in texture. It is usually moist or wet at from 18 inches to a few feet below the surface, and scattering iron concretions in quantities ranging up to 5 per cent are often present in both soil and subsoil.

This is an extensive type of soil widely distributed throughout the area surveyed and occurs in belts parallel to the seacoast or larger streams. The largest areas are just back from the present sea beaches, while the country farther inland than the present survey consists almost entirely of this type, in an uncleared condition, and fresh-water swamps.

The Norfolk fine sand occupies smooth, gentle ridges, having the highest elevation of any type in the area and adjoining streams and tide marshes, usually with abrupt bluffs sloping away inland to the sandy loam and swamp areas. Most of the fresh-water streams originate at the foot of these ridges from seepage, and consequently the sand is very generally separated from the other types by areas of marsh and Portsmouth fine sandy loam.

The Norfolk fine sand occurs at all elevations from tide level to the highest in the area, but is more generally found at the highest. It has the most rolling and marked topography of any type represented, except the Norfolk sand, and occasionally forms slight wind-blown dunes and hillocks.

Naturally this type is a light, well-drained, early soil, but throughout a large proportion of the areas, particularly on the sea islands, the elevation is so slight and the surface configuration of the country so level that the water table is never far from the surface, and the subsoil is often saturated at a depth of from 18 inches to 3 feet. The texture of both soil and subsoil favors free moisture movement, and the soil is very much benefited by underdrainage where the water table is too high. Deep-rooted crops, like the Sea Island cotton, particularly, demand underdrainage to secure the best results of which the soil is capable.

The Norfolk fine sand consists very largely of finely divided siliceous particles of marine deposition, laid down much as the Galveston fine sand is being laid down as beaches by wave action, tide, and wind. The sediments have been but slightly modified since their removal from the influence of the sea. Rains have removed the salt, the oxidation of the iron has produced the more brilliant coloring, forming concretions in some cases, and the accumulation of vegetable matter on the surface has given the soil its light-brown color and slightly loamy texture. In other respects it closely resembles the Galveston sand of the present beaches along the Atlantic and Gulf coasts. Variations in different areas of the type are due almost entirely to cultivation and drainage, and exert a marked influence on crop yields.

Long staple or Sea Island cotton is the only crop of great importance, and it is on this type that the industry has chiefly been established. This important special crop will be fully considered in the chapter on agricultural conditions. Yields vary from 200 to 400 pounds per acre, 300 pounds being a fair average. Few of the intelligent planters fail to secure the latter yield in a good season, yet few exceed that amount with any regularity. From 500 to 1,500 pounds of commercial fertilizer is applied per acre to secure this yield. White potatoes are grown to some extent, this type being a little safer than the sandy loam, though generally not yielding quite so heavily. Average yields vary from 100 to 250 bushels per acre, inclining toward the lower figure. Sweet potatoes yield well, and are grown principally on this type both for market and for stock food. Asparagus is more extensively grown on this than on any other type in the area, but is much subject to rust, and the acreage is decreasing. All kinds of light truck are grown to some extent. Green peas and cowpeas are often planted in the cotton rows late in the season, and some oats and grass crops are produced. Recent experiments indicate that alfalfa would succeed well on this type, and its introduction should be encouraged as a valuable addition to the crops of the area, not only for profit but for its beneficial effect on this loose type of soil. Grass and grain crops withstand the heat of the summer season with difficulty.

The Norfolk fine sand is admirably adapted to the production of those crops which it is desired to force to an early maturity, and with the advantage of a salubrious climate and ample rainfall, offers unbounded opportunities to the intelligent market gardener and truck grower. With the introduction of alfalfa many areas too inaccessible for trucking and cotton planting would become valuable as grazing lands. Longleaf pine makes a fine growth, and in view of the increasing scarcity of that timber, forestry in this section promises large returns in the near future.

The following table shows the texture of typical samples of the soil and subsoil of this type:

Mechanical analyses of Norfolk fine sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10676	Stiles Point, James Island.	Brown fine sand, 0 to 14 inches.	0.3	1.0	1.4	61.0	25.7	6.4	4.3
10674	Andells Bluff, Johns Island.	Brown fine sand, 0 to 12 inches.	.1	.6	1.4	82.3	9.1	2.1	4.4
10680	5 miles E. of Edisto, Edisto Island.	Brown fine sand, 0 to 12 inches.	.2	.7	.8	72.1	14.4	6.1	5.4
10675	Subsoil of 10674 ..	Yellow fine sand, 12 to 36 inches.	.0	.2	.9	82.9	10.0	1.9	3.9
10681	Subsoil of 10680 ..	Yellow fine sand, 12 to 36 inches.	.0	.3	.5	82.8	9.3	3.0	4.0
10677	Subsoil of 10676 ..	Yellow fine sand, 14 to 36 inches.	.1	1.0	1.3	62.9	25.0	5.5	4.1

NORFOLK FINE SANDY LOAM.

The soil of the Norfolk fine sandy loam varies from 4 to 14 or more inches in depth, having a general average of about 10 inches, and is a light to dark brown fine to very fine sandy loam, mellow, and light textured. The surface compacts slightly when wet, but crumbles readily on drying,

The subsoil, usually to a depth of more than 3 feet, is a yellow, reddish, or mottled drab and yellow sandy clay, close textured and massive, plastic and sticky when wet, and somewhat friable when dry.

This type occurs in irregular and scattered areas throughout this region, principally on Charleston Neck, the mainland, and the northern portions of the larger sea islands near the rivers. The seaward limit of its occurrence is quite uniformly throughout the length of the area at from 3 to 5 miles from the coast.

The Norfolk fine sandy loam occurs at all elevations from tide level to 20 or 30 feet above, but the greater proportion of the type lies at the lower elevations, with ridges of sand occupying higher elevations back from tide water. Its surface is generally level or only slightly inclined toward tide water. Depressions in it are usually occupied by swamp, or "black land," while any decided elevation therein gives sand.

No streams of any size originate in or traverse this type. On the banks of the small streams the heavy subsoil is exposed, forming brightly colored spots of heavy land, which, if more extensive, would constitute a new soil type. The soil is relatively thin on the necks of slight elevation, which are occasionally washed by high spring tides, and in these situations the soil is somewhat heavier than usual.

Natural drainage is very poor, and, except in a few favored localities, artificial drainage is necessary to bring this soil into good condition for cultivation. The surface soil is capable of fair natural drainage, but the subsoil is very impervious, keeping the soil in a nearly saturated condition. The low elevation has seriously retarded natural drainage, but the fall is sufficient in most cases to permit of good results by artificial means. Open ditches are in general use, also some board drains, and a small amount of tiling; all produce satisfactory and profitable results.

The Norfolk fine sandy loam is composed of fine sediments of marine origin, indicating a quiet water deposition. The abrupt differences in texture between soil and subsoil would seem to indicate a lapse of time between their deposition, or a change in the source of derivation of the materials, or in the force of the current effecting their deposition.

Owing to the low elevation and lack of drainage, weathering in this type has gone on only to a limited extent. The subsoil is largely bluish, showing iron salts in a low state of oxidation. In situations more favorable to drainage the subsoil has attained a bright yellow or orange color from more advanced weathering. In its natural state the soil is a light-brown color, except for a slight covering of fresh mold, but where long cultivated it has attained a rich brown color to a considerable depth and is more loamy. Pine, liveoak, scrub oak, gum, sycamore, hickory, and dogwood are the natural forest growth on this type. Very little longleaf pine is found on it, as the soil is not naturally adapted to this kind of timber.

The principal crops grown are cabbage and potatoes, and so exclusively that it is quite generally known locally as "cabbage land."

Yields vary from 150 to 250 crates of cabbage per acre, not including the plants which do not head and are sold for greens, adding considerably to the value of the crop. From 1 to 2 tons of high-grade fertilizer is added per acre to produce the above yields, and the crop is followed by corn, generally without fertilization, or by some other truck or general crop, thereby securing two crops each season from the soil. Potatoes are grown for early market and yield from 150 to 300 bushels per acre. Corn yields from 25 to 50 bushels per acre. Some cucumbers, beets, carrots, asparagus, lettuce, strawberries, etc., are also grown. The latter crops are more general around Charleston and the adjacent mainland.

Differences in yield are slight and depend more on drainage, fertilization, and cultivation than on the natural qualities of the soil, which is quite uniform throughout the entire area. Some Sea Island cotton is produced successfully on well-drained or tile-drained areas, the yield comparing favorably with that from the Norfolk fine sand. It is not so important a crop on the fine sandy loam as on the fine sand.

The Norfolk fine sandy loam is adapted to a wide range of the heavier truck and general crops which are suited to this climate and elevation. The long-staple cotton industry might become more general on this soil by careful attention to underdrainage. More attention to rotation and a greater variety of crops would likewise be advisable. Green manuring and the use of leguminous crops might will partially replace the heavy applications of mineral fertilizers at present so general. Pears, peaches, and plums of fine quality are produced, but the trees are said to be short lived and subject to disease, which might be largely overcome by proper treatment.

The following table shows the texture of typical samples of this soil:

Mechanical analyses of Norfolk fine sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10652	Youngs Island	Fine sandy loam, 0 to 10 inches.	0.4	1.0	1.4	37.5	26.8	26.2	6.5
10654	Martins Point, Wadmalaw Island.	Brown fine sandy loam, 0 to 10 inches.	.2	.6	.7	31.4	30.9	26.8	9.4
10656	1 mile NW. of Edisto, Edisto Island.	Brown fine sandy loam, 0 to 12 inches.	.2	.7	.7	31.4	38.8	28.1	10.1
10653	Subsoil of 10652	Sandy clay, 10 to 36 inches	.1	.7	2.0	48.5	18.6	9.1	20.7
10657	Subsoil of 10656	Sandy clay, 12 to 36 inches	.0	.2	.7	28.0	24.2	23.8	23.1
10655	Subsoil of 10654	Yellow sandy clay, 10 to 36 inches.	.0	.3	.4	25.5	25.8	19.7	28.3

NORFOLK SAND.

The soil of the Norfolk sand, as found in this area, consists of a light-brown or yellowish soil, composed mainly of coarse to medium sand particles and extending to an average depth of 12 inches. A small amount of iron concretions is occasionally found on the surface and mingled with the soil and subsoil, the proportion being greater in the subsoil, but not to an extent sufficient to affect the soil. Otherwise the type is uniform, but grades slowly into the surrounding types. The subsoil extends to depths greater than 3 feet, and consists mostly of coarse to fine grade sands of a yellowish color and similar in character to the soil. Occasionally it holds a small amount of silt in the lower depths, and is then slightly more loamy. The type in general is loose and incoherent, and furnishes the only sand in the area coarse enough for building purposes. From the presence of the iron concretions the type is locally known as "gravel land."

The Norfolk sand occurs in one long, nearly continuous area across Edisto Island, having a direction nearly parallel with the coast and an average width of nearly half a mile. In no other section of this area do sands of so coarse a texture occur. The Norfolk sand here occupies a gentle, rather well-defined ridge, elevated a few feet above tide marsh and sloping away on each side into the other types of the area, with which it blends for a considerable distance. It is no more marked or well defined than many of the fine-sand ridges throughout the area, and is of no greater elevation. From the nature of its component materials, the surface is naturally well drained, and the whole type offers little resistance to the movement of soil moisture. The water table, however, is so near the surface that the subsoil is often moist or wet at no great depth. No streams are found on this type, but rain water percolates rapidly through it, and oozes out in springs and marshes at the base of the ridge. In the cultivation of deep-rooted crops, like the long-staple cotton, to secure the best results it is generally necessary to lower the water table by underdrainage.

The type is of sedimentary origin and indicates a deposition from stronger currents than those which gave rise to the other types of the area. No explanation is suggested for the occurrence of this solitary ridge of comparatively coarse material in this broad expanse of fine sediments. On account of its loose and open texture, weathering has proceeded to a considerable extent, leaching and altering the iron and other soluble matter. Consisting so largely of silica, little change has been wrought in the texture of the type, the slight differences between soil and subsoil having been brought about mainly by cultivation and the incorporation of vegetable matter.

Sea Island cotton is almost the only crop grown on this type, and no differences in yield or quality are noticed between fields on this type and on the Norfolk fine sand. It is well adapted to the crop, and under proper cultivation will produce 300 pounds to the acre. Some sweet potatoes, truck, and general crops are grown, yielding on the average about as well as on the Norfolk fine sand. The acreage of other crops is too small to form an accurate estimate of the natural productiveness of the Norfolk sand here. It is suited to early light truck and cotton, but less suited to general crops. The yields and quality of the cotton would seem to be more dependent on cultivation and climatic conditions than on slight differences in the actual physical texture of the soil.

The following table shows the texture of typical samples of the soil and subsoil of this type:

Mechanical analyses of Norfolk sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10691	1½ miles SE. of Edisto, Edisto Island.	Light-brown coarse and fine sand, 0 to 12 inches.	3.2	26.9	9.2	49.2	5.5	1.7	4.2
10689	3 miles S. of Edisto, Edisto Island.	Coarse and fine sand, 0 to 12 inches.	2.7	21.3	6.3	53.3	9.9	1.7	4.7
10692	Subsoil of 10691..	Yellow coarse and fine sand, 12 to 36 inches.	3.4	25.3	8.9	50.6	4.6	1.8	5.3
10690	Subsoil of 10689..	Coarse and fine sand, 12 to 36 inches.	3.2	20.9	5.8	51.1	9.6	2.7	6.5

PORTSMOUTH FINE SANDY LOAM.

The soil of the Portsmouth fine sandy loam varies in depth from 8 to 18 inches, averaging 12 inches, and is a black or rust-brown mucky fine sandy loam, compact, wet, and heavy. A relatively large proportion of organic matter is present in all stages of decomposition, imparting to the soil the deep color. This constituent gradually disappears with continued cultivation, the soil becoming lighter in texture and the sand content more pronounced.

The subsoil is usually a mottled drab and yellow sandy clay, massive and sticky, and extends to a depth of more than 36 inches. Occasionally the subsoil is underlain at depths slightly less than 36 inches by a layer of gray or white very fine sand, and where the type occurs within sand areas the subsoil often consists entirely of sand and has a bleached appearance.

This type includes the fresh-water swamps and marshes of the area, which are filled with standing water the greater part or all of the year and covered with a heavy growth of cypress, gum, and magnolia, together with other water-loving trees, shrubs, and undergrowth. Loaded down with masses of gray Spanish moss and outlined against the clean growth of pine which surrounds them these trees form a distinctive feature of the landscape. But little of the area of this soil is cleared and only a small percentage is under cultivation.

The type occurs in narrow bands along all the fresh-water streams, around the heads of tide marshes beyond salt-water limits, and in large areas inland at the foot of sand ridges, where it is formed by seepage. The areas are of irregular outline and follow the direction of natural surface drainage.

The Portsmouth fine sandy loam is characterized by level, depressed, or inclined surface features, the inclination being always in the direction of the longest axis of the area It is found at all elevations above tide level, but always a little lower than the Norfolk fine sand or other adjacent agricultural types. Most of the fresh-water streams traverse this type with very slight fall, and any elevations in it are occupied by some other soil type.

Lack of drainage is responsible for the existence and peculiar characteristics of the Portsmouth fine sandy loam, which owes its origin to swamp and marsh development on the Norfolk fine sand and Norfolk fine sandy loam, which has so modified the texture, appearance, and crop value by the accumulation of decaying vegetable matter and the effect of the organic acids derived therefrom on the soil particles as to form a distinct type of soil.

In most cases drainage is possible and the fall sufficient to insure complete reclamation of large areas. Some large tracts on James Island have been drained and will soon form desirable farm lands. Elsewhere in the area little has been done in this direction beyond a little clearing around the edges. Much valuable timber, at present inaccessible with ordinary lumbering conveniences, remains in the swamps.

The mineral particles which compose this type were laid down as a marine sediment, and are identical in origin and manner of deposition with those of the Norfolk fine sand and Norfolk fine sandy loam. On account of its saturated condition atmospheric weathering has been very limited, but chemical changes have resulted from the liberation of organic acids from the excess of vegetable matter on the surface and in the soil. These organic remains have made the soil compact, heavy, and mucky.

Only a small percentage of this type is cleared, and crop interests on it are limited. Irish potatoes are successfully grown when the season is dry enough at the time of planting; otherwise the seed rots before sprouting. Cabbages do well and are perhaps best suited to the type of any crop at present grown on it. Cotton does fairly well on fields that have been well drained, but is very liable to disease. The acreage of cotton on this type is insignificant. Small patches of rice are grown for home consumption on wet areas, also of green peas. Corn gives a fair yield in favorable situations.

The Portsmouth fine sandy loam is well adapted to onions, blackberries, and dewberries, and where favorably situated as regards shipping facilities their production would be profitable. Drainage improves this soil type. In most cases the value of the timber would more than balance the cost of drainage, but concerted action would be needed to accomplish much in that direction.

The following table shows the texture of typical samples of this soil:

Mechanical analyses of Portsmouth fine sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10662	West side of James Island.	Black fine sandy loam, 0 to 12 inches.	0.2	1.4	1.6	43.6	16.2	24.8	12.1
10666	2 miles N. of Youngs Island.	Black fine sandy loam, 0 to 14 inches.	.3	1.5	2.0	42.7	15.5	24.9	12.9
10663	Subsoil of 10662..	Yellow sandy clay, 12 to 36 inches.	.2	.6	1.0	38.7	12.7	16.5	30.4
10667	Subsoil of 10666..	Yellow mottled clay, 14 to 36 inches.	.0	.2	.8	44.0	10.1	11.3	33.4

GALVESTON FINE SAND.

The soil of the Galveston fine sand, to a conventional depth of 12 inches, consists of a light-gray fine sand, containing varying amounts of shell fragments. It is very loose and incoherent, and contains little coarse material and almost no silt or clay. The sand particles are well rounded.

The subsoil is similar in texture to the soil, but usually contains less shell fragments, and has thin strata of black hornblendic material from a few inches to a foot in thickness. The subsoil is usually saturated at slight depths. No line of demarcation is observed between soil and subsoil.

This type occurs only along the sea front, in narrow bands from Morris Island to Bay Point. It rises in a gentle slope from the shore line back beyond the limit of wave action, where it forms low dunes, and descends inland by a gentle slope to the tide marsh and other types which join it. This type forms the familiar beaches of the Atlantic and Gulf coasts and is very uniform in texture. In this area it does not rise more than 20 feet above present tide level. The soil has thorough natural drainage, but the subsoil is always moist at slight depths. Its texture offers little resistance to the movement of soil moisture.

The Galveston fine sand is of marine sedimentary origin and of comparatively recent date. It is being deposited by wave and tide action even at the present time along the seacoast. No changes have taken place since deposition, and it scarcely comes within the definition of a soil, being almost pure rock fragments, lacking in organic and readily soluble matter.

None of the type is cultivated. A few bushes, cedars and yucca, make a stunted growth on the dunes, and farther inland, beyond the reach of the salt water, dense groves of palmetto and bay trees thrive.

The palmetto trees are a source of profit from their timber, which is much used for piling, and the leaves find a sale in the market for ornamental purposes.

The following table shows the texture of typical samples of the soil and subsoil of this type:

Mechanical analyses of Galveston fine sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10682	Bay Point........	Light, gray fine sand, 0 to 12 inches.	0.1	1.7	2.3	89.5	5.6	0.3	0.4
10683	Subsoil of 10682..	Gray fine sand, 12 to 36 inches.	.1	1.3	2.4	88.9	6.9	.2	.3

GALVESTON CLAY.

The Galveston clay is the familiar salt marsh common along the Atlantic and Gulf coasts and the bays and indentations of the sea.

The soil has an average depth of 12 inches and consists of dark-brown clay, wet, heavy, and plastic. In this area, around its inland limits much of it has been modified by the fine sands blown and washed into it from the surrounding soil types. Away from these influences it is uniformly a heavy clay, mixed with reeds, grass, roots, and decaying vegetable matter.

The subsoil from 12 to 36 inches is either a bluish silt and clay or consists almost wholly of roots. In composition it is soft and plastic, having the consistency of mortar; but on drying it becomes hard and massive. Roots and peat are always present in varying proportions, the latter frequently in a definite strata. The subsoil is often underlain below 3 feet by a layer of dense, massive blue clay.

The Galveston clay borders all the salt-water streams and channels of the area, is of wide extent near the coast, and extends in narrow, tortuous areas far inland to the limit of salt tides. Always level or only very slightly inclined toward water, and submerged by every high tide, it is totally lacking in natural drainage.

The areas of the Galveston clay are cut by innumerable winding salt-water channels and are almost impassable. When diked to exclude the salt water, and drained, it becomes a compact clay soil, brown when wet and gray when dry. Reclamation is feasible on large areas near the inland limits of salt water. The average rise and fall of the tide in this section being from 5 to 6 feet, considerable drainage is afforded at ebb tide. Some of the type has been thus diked and reclaimed on Jehossee Island and vicinity and is used for rice under irrigation. Some reclaimed areas have been abandoned as a result of changed conditions since the civil war. Large cypress and cedar stumps and roots occurring in some of the tide marshes indicate that recent changes in elevation have taken place and the salt marshes have encroached on former fresh-water areas and lands. A plantation survey, dated 1808, shows and describes as cypress swamp what is now an extensive tide marsh between Wadmalaw and Johns islands. In other sections of the area saltbushes indicate the positions of former tide marshes which are beyond the reach of recent tides, showing unequal movements of the land surface.

The Galveston clay is of sedimentary origin, being a recent alluvium deposited by salt tides in quiet waters, and consists of fine particles subsiding from the thin layer of quiet water mingling with the roots and stems of reeds and water-loving plants. Little change has taken place since sedimentation, atmospheric weathering being impossible. After reclamation the type compacts to a heavy, dense soil, difficult to till but well adapted to the production of rice.

In its natural condition it supports only saltbushes, reeds, and a variety of cedar. The reeds are sometimes cut and used for bedding, stable absorbent, and composting. Marsh mud is itself used as a fertilizer, mainly for physical benefit on light soils; but it is situated close to phosphate deposits in this area, and is claimed by many to contain a valuable proportion of that mineral.

Until land attains a higher value, most of the type will remain in its present condition of inaccessible marsh.

The following table shows the texture of this type:

Mechanical analyses of Galveston clay.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10685	Church Flats	Brown clay, 0 to 12 inches	0.2	0.7	0.6	14.2	7.2	31.3	45.4
10687	Bees Ferry, Ashley River.	Dark, brown clay, 0 to 12 inches.	.1	.7	.7	14.8	8.7	25.9	49.0
10686	Subsoil of 10685	Blue silt and clay, 12 to 36 inches.	.1	.1	.7	14.9	10.7	34.2	39.3
10688	Subsoil of 10687	Blue silt and clay, 12 to 36 inches.	.0	.1	.2	11.5	8.8	33.0	46.2

AGRICULTURAL METHODS.

Although the land holdings are large and the planters few in number, the cultural methods employed in growing the various crops of the area are fairly intensive. This is made necessary by the character of the principal products, and it is possible by reason of the sufficiency and cheapness of field labor.

From the low, level character of the land and consequent insufficiency of natural drainage, ridge culture is almost exclusively practiced on all crops grown, thereby enabling a certain latitude to be secured in cultural control of surface moisture conditions, the ridges being leveled by plowing down in dry spells and again thrown up should prolonged wet seasons ensue.

A single horse and light implements are in general use, both for plowing and fitting seed beds and for subsequent cultivation. Plowing is usually from 3 to 6 inches in depth, two furrows being turned together, forming a planting ridge and leaving a trench between to secure rapid drying of the field. The surface soils of most of the land under cultivation are so mellow and friable that little harrowing is necessary, and for general crops not planted in ridges the disk harrow is often used instead of the plow.

Sea Island, or long-staple, cotton is the chief and almost exclusive crop on the Norfolk fine sand and Norfolk sand, and is found to a slight extent on the Norfolk fine sandy loam and Portsmouth fine sandy loam. It requires cultural methods peculiar to itself to produce a good yield and fine quality, and while these methods vary within narrow limits with the fancy and experience of the individual grower, they are fairly uniform throughout the area and yields and quality vary but little.

The cotton fields are generally planted every other year, and in alternate years are allowed to lie fallow and are used as pastures for stock, which, in feeding on the stalks, follow the rows and by their continual tramping compact the trenches or alleys between, which are to form bottoms of future cotton rows.

In preparing the fallow fields for the succeeding crop the stalks from adjoining rows are "listed" or hoed onto the compacted alley, fertilizers are applied, and the row ridged up over the former alley by turning double furrows with a plow. The special aim is to secure the early maturity of the boll, so as to prevent its loss from early frost in the fall. The natural habit of the plant is to form a perennial shrubby growth with scant fruiting. To accomplish the desired result the prolonged growth of the plant must be checked and its "blowing" or fruiting hastened. The compacted bottom of the row facilitates this by confining the root zone. Liberal fertilization is also given to hasten maturity. Underdrainage is practiced with the specific object of securing a dry root zone during the fruiting season, in order that the plant will not be encouraged into rank or weedy growth and that its bearing may be stimulated. Early maturity has doubtless, by these various means of encouragement practiced through a long period, tended to become more and more an ingrained character of the plant itself, transmitted through its seed, and thus by cultural methods has the natural habit of the plant been radically changed, its present manner of growth and time of fruiting being highly artificial.

The seed is planted by hand during the latter part of March or early part of April, according to climatic conditions, in rows 5 feet apart, using about 35 pounds of seed per acre. The plants are subjected to thorough surface cultivation until too large. Picking begins in the early fall and lasts sometimes until nearly the end of the year, the crop demanding attention for nearly nine months.

One thousand pounds per acre is the average amount of fertilizer applied. A proportion in general use is 400 pounds cotton-seed meal, 300 pounds kainit, and 400 pounds dissolved phosphate. Nitrate of soda, fish scrap, and marsh mud are sometimes applied. Peas are frequently sown in the cotton, and aside from the profit derived from the crop, are of benefit to the soil, and serve the additional purpose of keeping the field free from nut grass, by so shading the ground after the cotton leaves have wilted that the nut grass is unable to mature seed or form the little burrs or nuts by which it propagates, being thus eventually killed out.

The cabbage fields are plowed in ridges by turning two furrows together, rows being formed 2½ feet apart. About 1,500 pounds per acre of high-grade fertilizer is applied before planting. The young plants from the seed bed are set from 12 to 18 inches apart in the row. They receive frequent tillage with diamond-tooth cultivators, sweeps, and occasional subsoiling to a depth of from 8 to 12 inches with a small subsoil plow, for aeration and removal of surplus moisture. Occasional applications of nitrate of soda and commercial fertilizers are made as a top dressing to force the growth, the total application ranging from 2,000 to 4,000 pounds per acre. The cabbage crop is almost entirely grown on the Norfolk fine sandy loam, as it requires a large moisture supply retained near the surface. It is followed the same season, usually by corn as a general crop, and in a smaller acreage by cucumbers. The following season potatoes are planted after the cabbage, giving four crops in two seasons. Sometimes a field is left in fallow one season and the natural growth turned under.

Methods in use on potatoes, corn, cucumbers, beets, carrots, and market garden crops do not differ materially from practices in other sections and do not demand special consideration.

Strawberries are cultivated in narrow matted rows, mulched with pine straw, which is raked off from the plants in early spring by hand labor. Large amounts of stable manure, compost, and nitrate of soda are applied to this crop.

Irrigation is practiced on the rice lands on Jehossee Island. Only a small acreage of this important crop falls within the limits of this area, and not enough attention is paid to this crop to warrant a discussion of its culture in this report. Recent attacks of blight have seriously threatened the existence of the industry in this section.

AGRICULTURAL CONDITIONS.

Agriculture in the Charleston area is carried on principally by white planters of a high degree of intelligence, culture, and refinement. They are almost without exception in comfortable or affluent circumstances, favored with an equable climate and easily tilled, responsive lands, enjoying an ideal country life, with time and opportunity for research and experimental work in agricultural lines, of which opportunity many of the foremost have availed themselves, with much profit to the community. The plantations are generally worked by the owners, and most of them are free from incumbrance. Many are leased out in small parcels to colored people, who make payment in a portion of the crop, or, more frequently, in a stated amount of labor performed on lands worked by the owner and lessor.

The farms are of large size, running from several hundred to several thousand acres in extent, but usually only a small acreage of each plantation is under cultivation, a large part of the area being in forest or old fields. It is not uncommon to see old cotton rows in fields now covered by forests of thirty to forty or more years' growth. James Island is probably the best cleared area of the section, closely followed by Edisto Island, and then by Wadmalaw Island. The part of mainland included in this survey is cleared only in narrow strips along main roads, and the water front and Johns Island are uncleared except for occasional small areas along the shore. The interior, with its dense pine forests and mazes of cypress swamps, is almost impenetrable. Few white people live on this island, and the large colored population derives an existence from agricultural pursuits and the natural food supply of forest and stream.

Field labor is done by colored people entirely, who are paid about 50 cents a day. Labor is adequate but unskilled. Few hands are employed by the day or month for a cash wage, most of the help being "contract hands" who have been furnished a cabin, firewood, and the use of a piece of land in consideration of their working two days a week for their employer. They, with the help of other members of their family, make a crop on the land furnished them in their spare time. Contract hands often put in more than the stipulated time, and are paid at the prevailing rate in plantation checks good for their face value at the "commissary" maintained on the plantation.

The farm buildings consist of the large, roomy plantation house of two or three stories, set high above the ground, facing the south, and having ample piazzas on that side and a more or less imposing flower garden in front. The houses are all built light and airy for summer comfort, and afford little protection from the occasional cold spells of the winter season. Open fireplaces furnish the little heat needed and add much to the cheerfulness of the long evenings. The houses are often approached by long avenues, lined on each side with magnificent liveoaks, their spreading limbs hung thickly with Spanish moss and ferns. The whitewashed negro cabins, with their stick-and-clay chimneys, are ranged around the edges of the fields or line the lanes leading to them. The dock and warehouse are a necessary part of the farm equipment, as most of the plantations are located on navigable channels, and most of the supplies are received and shipments made by water. Tool sheds, a few stalls for the stock, the commissary, and, on the larger plantations, a cotton gin, complete the equipment. No large barns, and few fences, are seen. Implements are of modern pattern, but chiefly light and intended for one-horse cultivation.

Because of the character of the labor much of the work is done by hand implements which in other sections would be accomplished with teams and team implements. White foremen are generally employed, and experienced men are required to handle the class of labor under their charge. The laborers seem contented, and often remain many years or a lifetime on the same plantation, though some of the more enterprising find employment at some trade in the city.

The crop interests of the Charleston area can not be called diversified, as they naturally fall into but two classes—cotton and truck—other general crops representing but a small acreage.

Long-staple or Sea Island cotton is preeminent in interest among the products of the area. Growing only at an altitude slightly above sea level, and within a narrow range of climatic conditions, it here reaches its perfection of length and quality of staple and yield near the northern limit of its zone of growth. Originally a perennial shrub bearing scanty bolls, it has been made by cultivation to put forth more and earlier fruit pods and longer, silkier staple, until now the seed carries within it these artificial and ingrafted qualities which quickly degenerate when it is taken from its accustomed surroundings to a different climate or elevation. It is best adapted and most widely grown on the type known as Norfolk fine sand, although no difference can be detected in adaptation between that type and the Norfolk sand. It is grown to some extent on the Norfolk fine sandy loam, which is not so well adapted to it unless thoroughly underdrained, because of the larger moisture capacity of its subsoil and consequent tendency to prolong the growth and delay maturity. Underdrainage is beneficial because the ready percolation of water through the soil into drains bears away the hardpan which tends to accumulate or " clog " just above the water table on undrained lands. This permits soil moisture (not free water) to be conveyed back to the plants through these opened channels, instead of remaining dammed in beneath the hardpan. At the same time the water table is lowered, and since the plant and upper soil are uniformly supplied with moisture, the roots are not stimulated into an excessive growth toward the water table, and the growing season thereby lengthened. For this same reason the " gravelly " subsoil is good for long-staple cotton. (Soils containing iron concretions are here called " gravelly lands ".) Yields vary from 200 to 400 pounds per acre, 300 to 350 being considered a good yield. The product is ginned by specially constructed gins, using no saws to cut the fiber, into " bags," which are not subjected to nearly as much pressure as is used in baling short-staple cotton, as this would break the fiber and injure the quality. Nearly all the crop is exported, the last season's product bringing from 25 to 60 cents a pound. Only a few lots from Edisto Island brought the top price.

Most of the growers contend that it is more profitable to raise a large yield of the medium quality than a smaller yield of the highest quality, which demands so much expert care and attention. The crop yields an average of 1,000 pounds of seed per acre, having a value of about $1 per bushel of 44 pounds for seed purposes, or $18 a ton for milling purposes. The best planters find ready sale for theirs for seeding, as northern-grown seed is much in demand by growers farther south, from its tendency to an earlier maturity. The crops grown by the colored people have no established quality, and the seed is marketable only for milling. Recent high prices have induced some to plant short-staple cotton on the sea islands, and many growers have expressed a fear that this may result in ruining the reputation of their Sea Island cotton seed, or eventually destroying the peculiar qualities of the long-staple crop here.

The progress of the Sea Island cotton industry has not been without its vicissitudes. At one time the blight or " wilt " threatened its complete destruction and many experiments and remedies were tried, resulting in failure or only scanty success. It is due chiefly to the efforts of Mr. Elias Rivers, a scientific planter on James Island, seconded by the efforts of the Bureau of Plant Industry of this Department, that this trouble has been largely overcome. By a careful and intelligent selection of seed from plants immune to the disease he has successfully combated it, and others have quickly profited by his success. These immune plants have a tendency to make a little coarser growth and bear a trifle larger seed. The cotton of finest quality is most susceptible to blight.

"Blue cotton" is a disease that has given trouble in some sections. The plant attains a good growth, and then falls down without bearing and sheds its pods. The cause is attributed to an excess of iron in the soil, and large concretions are often found on affected land. It may possibly be due to the acidity of iron sulphate and associated sulphuric acid and humic compounds which have accumulated. It is claimed that the "fillers" (body) of commercial fertilizers contain iron and sulphuric acid, and that this increases acidity, becoming thereby a contributing cause of the disease. The remedies are: Lime and underdrainage to facilitate leaching of humic compounds, applications of salt wash, and thorough composting of applied manures to prevent the accumulation of raw organic matter.

Last season some 9,000 bales of Sea Island cotton were ginned in South Carolina, nearly all of which was produced within the limits of the present survey, and the industry is now in a thriving condition, but with no tendency to an increased acreage.

Of the truck crops cabbage is the most important, followed by potatoes, strawberries, cucumbers, and beets. Of less importance are asparagus, lettuce, radishes, carrots, and melons. The cabbage crop is confined almost exclusively to the Norfolk fine sandy loam, with a small acreage on the Portsmouth fine sandy loam, and the areas in this crop are located on the water fronts of the inland rivers from Charleston to Slanns Island, except for a few miles from Johns Island ferry to New Cut, on Wadmalaw Island, and a few small areas on James and Johns islands. Very little cabbage is grown on Edisto Island. The industry centers at Meggett station, where over 5,000 acres are planted this season (1904). One field of 750 acres was a beautiful sight at the time of the survey, when cutting was just commencing. Two crops are grown, one maturing for the spring shipment, which is of exceptional importance. Several varieties are grown, but the bulk are of the Wakefield type, the favorite being the Charleston Wakefield, a variety orignated by Mr. F. W. Towles, of Martins Point, who is the pioneer truck grower of the section. The heads are cut and trimmed in the field, drawn to the warehouse or packing shed, and packed in crates containing about 100 pounds, net, of cabbage. These crates bring from $1.50 to $5 each on the market. Yields vary from 150 to 230 crates per acre. Crates cost from 12 cents to 15 cents each and are not returned. Loose heads are disposed of as greens, and leaves and trimmings fed to stock. Northern-grown seed is in general use, to secure earliest maturity. Millions of young plants are shipped from the seed beds here to other growers farther north and bring about $1.50 per thousand.

Early potatoes are produced extensively on the cabbage lands in rotation. The Early Rose is the favorite variety, and is grown from northern-grown seed, yielding an average for the entire area of 100 bushels per acre. Many growers secure regularly from 200 to 250 bushels per acre.

Asparagus was formerly much grown, but the acreage is rapidly decreasing on account of changed market conditions. It is grown mainly on the Norfolk fine sand. The average yield is 25 crates per acre. Strawberries are extensively grown around Charleston on the Norfolk fine sandy loam. Sweet potatoes are grown on the sandy soils. They yield an average of 200 bushels per acre, and are used largely as stock feed and for the table, few being shipped from this section.

The Atlantic Coast Line Railroad traverses the mainland of the area, with several spurs and branches into the trucking section. The Southern Railway also enters Charleston, and the Clyde Line steamers make frequent trips to northern ports. Transportation to and from the islands is entirely by boat, several steamers making regular trips during the market season.

With few exceptions, the roads are very sandy, and there is no construction material at hand aside from oyster shells.

Cotton is exported, and the truck crops are shipped mostly by rail to the northern markets, even as far as Boston and Providence. An effort is being made to develop the western market for cabbage and potatoes, and an association of the principal growers has recently been formed in the endeavor to decrease internal competition and to prevent ruinous prices and the oversupplying of markets.

SOIL SURVEY OF DODGE COUNTY, GEORGIA.

By CHARLES W. ELY and A. M. GRIFFEN.

LOCATION AND BOUNDARIES OF THE AREA.

Dodge County lies in the south-central part of the State of Georgia, and is bounded on the northwest by Pulaski County, on the northeast by Laurens and Montgomery counties, on the southeast by Montgomery and Telfair counties, and on the southwest by Wilcox and Pulaski counties. The county is comprised between 82° 53′ 33″ and 83° 27′ 27″ west longitude and 31° 54′ and 32° 26′ north latitude. Eastman, the county seat, near the center of the county, is about 130 miles southeast of Atlanta. The county is roughly rectangular in shape, and has an area of 313,088 acres, or about 489 square miles.

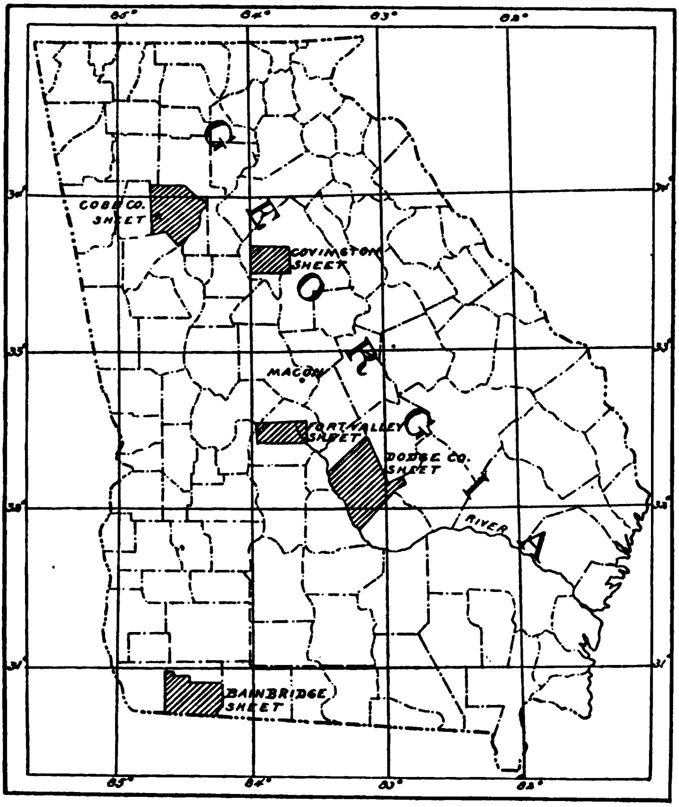

FIG. 8.—Sketch map showing location of the Dodge County area, Georgia.

During the latter part of the survey the writer was assisted in the field work by Messrs. Herbert W. Marean and W. E. McLendon.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Dodge County was erected out of portions of Pulaski, Montgomery, and Telfair counties in 1871. These counties, together with Laurens, had a population of only 8,000 in 1810. The settlement of the country comprised in Dodge County was even slower than in other parts of this region, for as late as 1865 one could have driven from the present site of Eastman to Hawkinsville, a distance of 20 miles, without passing a single house.

The country consisted originally of extensive pine forests, broken only by swamps or the different vegetation of the sand areas. The entire uplands were covered with a good growth of wire grass, with scarcely any underbrush. This furnished good pasture, and the attention of the earliest settlers was turned to the raising of live stock—chiefly cattle and sheep. At one time this formed an important industry.

The Georgia Central branch of the Southern Railway was built through Dodge County in 1871, and soon afterwards lumber companies came into the region and bought or leased the timber rights to large tracts of land. The forests were rapidly removed, and twelve or fifteen years ago nearly all the merchantable timber had been cut. The turpentine industry also throve for a while, and a small quantity is made in the county to-day.

Early in the seventies settlers began to come into the county from surrounding counties and from northern Georgia, and as the timber was removed the land open to cultivation was taken up. This diminished the area of pasture and caused the cattle industry to decline. More grain was grown at that time than now, though cotton has long been the important crop. Tobacco also was grown for home use, but its cultivation is now practically abandoned.

Under the constant cultivation of cotton, with little attention to manuring or to the rotation of crops, the natural productivity of the lands has declined and commercial fertilizers are used very generally.

The Wrightsville and Tennille Railroad and the Seaboard Air Line, laid about 1889, have been instrumental in building up the northern and southern parts of the county, but there are yet 80,000 acres of land which have never been under cultivation. Many settlers are at present coming into the county and establishing homes on this land, which is held at a low though advancing price.

The present population of the county is 13,975, the whites predominating.

CLIMATE.

The following table, compiled from the records of the Weather Bureau, shows the normal monthly and annual temperature and precipitation at the stations named. Hawkinsville is about 18 miles northwest of the center of Dodge County, and Dudly is about the same distance northeast.

Normal monthly and annual temperature and precipitation.

Month.	Hawkinsville.		Dudly.		Month.	Hawkinsville.		Dudly.	
	Temperature.	Precipitation.	Temperature.	Precipitation.		Temperature.	Precipitation.	Temperature.	Precipitation.
	° *F.*	*Inches.*	° *F.*	*Inches.*		° *F.*	*Inches.*	° *F.*	*Inches.*
January	45.9	4.33	47.3	3.23	August	78.9	6.55	81.4	5.03
February	47.1	5.89	48.3	5.28	September	74.7	3.17	77.3	3.55
March	56.8	6.12	58.8	4.74	October	66.1	3.57	67.0	3.86
April	64.7	2.85	64.3	3.94	November	53.8	2.53	56.9	4.01
May	71.0	2.44	75.3	2.51	December	46.6	3.48	48.1	4.21
June	77.9	5.30	82.8	3.13	Year	63.6	52.60	65.9	48.75
July	79.8	6.87	82.8	5.26					

The greatest precipitation occurs during February, March, and the summer months. The others have a fairly uniform distribution of rainfall, ranging from 2.35 inches to 4.21 inches. The maximum temperature in summer does not often exceed 100° F., and the minimum in winter rarely goes below 20° F. Occasionally, at night, the ground freezes to the depth of half an inch, but generally thaws during the day. Snow is seldom seen.

The average date of the last killing frost in spring is March 14, and of the first killing frost in fall November 11. This gives a growing season of 240 days. However, during the last eleven years there have been times when frost occurred as late as April 1, and as early as October 24. At times, though rarely, the fruit buds, started by unseasonably warm spring days, are subsequently damaged by late frost.

PHYSIOGRAPHY AND GEOLOGY.

In a general way the topography of Dodge County is that of a gently rolling plain, cut by sluggish streams with only moderate slopes along their courses. Ultimately the drainage of nearly the entire county flows into the Ocmulgee River, but in the northeastern part of the county the waters enter several good-sized tributaries before reaching the larger stream. The Little Ocmulgee River, or "Gum Swamp," as it is popularly known, passes through the county in a generally southeast direction, a few miles to the northeast of its center. Waltons Creek enters this stream some 6 miles north of Eastman. Sugar

Creek—a stream rising within the county—is only a few miles southwest of these streams, and flows in the same general direction. These three, with their tributaries, drain nearly all the central, northeastern, and southeastern parts of the county. All the streams, except the Ocmulgee River, are characterized by narrow bottoms entirely covered with water during most of the winter and other rainy seasons. In summer the streams dry up to such an extent that the current entirely ceases, and the stream course is marked only by pools. For a great part of their length on each side of the present bottoms wide, flat or very gently rolling areas of sand are seen. On the edge of these the land rises, usually gradually, but sometimes abruptly, from 30 to 60 feet.

A more or less prominent ridge separates the waters of Sugar Creek from those of the Little Ocmulgee River. The Southern Railway runs along the crest of this ridge, and Eastman, Chauncey, and Empire are situated thereon. Eastman is 361 feet and Chauncey 300 feet above sea level. Similar ridges frequently occur between the smaller streams. The crests of these ridges are covered with Norfolk sandy loam and the slopes with the Norfolk sand, and their location can be made out on the soil map from this circumstance.

To the southwest of Sugar Creek a divide, somewhat similar in character to the one just described, separates the waters which enter the Ocmulgee River from those which flow to the southeastward. This ridge is not so pronounced as the others, but is more like a gently rolling plain of higher land, with ridgelike outliers extending down between the streams. Beyond this the drainage is to the southwest. In some places at the edge of this divide, facing the river or its tributaries, even the smaller streams have cut V-shaped channels 40 to 60 feet deep, and some of the most hilly land in the county is seen here. Nearer the river the land becomes gently rolling again, with shallow stream courses. A flat, low-lying deposit of sand, similar to that found along the other streams, occurs near the river and the bordering bottom lands. In the vicinity of Rhine this flat land widens out up the creeks, and there is a slight rise near the river of 10 to 20 feet. The upland always meets the bottom land in a gentle slope, and even where it extends to the river bank in few places is it over 15 or 20 feet above the bottoms.

No geological survey of Dodge County has yet been made, so that the age of the formations can not be stated. The gray and yellow sands and sandy loams and yellow clays which constitute the upland soil types are usually 6 to 15 feet thick, underlain by a mottled gray and red sandy clay, which sometimes changes to a gravelly clay, and at other times becomes very sandy. In a few places this sandy phase has been consolidated into sandstone, probably by iron salts.

The red and gray clays are quite tenacious, and in wells stand in perpendicular walls without curbing.

Along one of the creeks from 3 to 5 miles southeast of Eastman a few outcrops of limestone are seen. For a distance of perhaps 2 miles this stream has eroded away the overlying material and cut its channel from 10 to 20 feet deep into the limestone rock. This formation undoubtedly underlies much of that part of the county, for many sink holes are found there. These range from 30 to 60 feet in diameter, and from 10 to 30 feet in depth. They occur on the tops of hills, on slopes, and in various positions, but most often near the stream. A few similar sink holes were seen in other parts of the county.

SOILS.

Three types of soil, exclusive of Meadow, were recognized in this county. The following table shows the area of each type:

Areas of different soils.

Soil.	Acres.	Per cent.
Norfolk sand	175,296	56.0
Norfolk sandy loam	105,792	33.7
Meadow	19,584	6.3
Norfolk coarse sand	12,416	4.0
Total	313,088	....

NORFOLK SANDY LOAM.

The Norfolk sandy loam consists of a light-brown or gray sandy loam or sand, from 6 to 10 inches deep, underlain by a yellower material of the same texture, beneath which, at from 12 to 24 inches, occurs a yellow loam or sandy clay. The average depth to the clay is about 16 inches. Over the surface of most of the type are scattered numerous rounded iron concretions from one-fourth to one-half inch in diameter, which give to this soil its popular name of "red pebble land." As a rule these concretions do not extend deeply into the subsoil. When the land is freshly plowed they are not conspicuous, but become so after rains have beaten down the surrounding soil. In extreme cases they almost cover the ground. On narrow divides some quartz gravel is also found on the surface of this type. Usually, however, as the stream course is approached both soil and subsoil become lighter in texture, the red pebbles disappear, and the type grades into the Norfolk sand.

This soil is locally known as "hard land," from its tendency to become compact when not stirred for some time. Except in the depressions, roads over this type are hard and smooth, with very few stretches of sand, and are easily distinguishable from those through the more sandy types of soil.

Certain red or gray clays underlying this type, usually at considerable depths, outcrop in a few places and give rise to a soil which is somewhat different from the Norfolk sandy loam, but owing to the small extent of such areas they were not mapped as a separate type.

The Norfolk sandy loam is found in all parts of the county, but its greatest relative development occurs northwest, west, and south of Eastman, in and around Chester, to the northwest and west of Milan, and in the western part of the county. This type covers nearly all the gently rolling uplands of the county, the more hilly slopes and the lower, flatter land near streams being covered with Norfolk sand. The most extensive areas are found on the divides. A few flat or gently sloping areas are seen near the Ocmulgee River.

Owing to its gently rolling surface and relatively high position, the Norfolk sandy loam is usually well drained, but occasionally open ditches are seen on the more level areas, and such are undoubtedly beneficial. The soil does not suffer from excessive drainage, as does the Norfolk sand, and it stands drought much better. It washes badly, and contour cultivation and terracing are practiced. All except the most level areas are likely to suffer serious damage from this tendency to wash.

The Norfolk sandy loam is derived from the yellow sandy clays already mentioned. The decay of the roots of the wire grass and accumulated pine needles has incorporated some organic matter in the first few inches of the soil, and cultivation has either increased or diminished this store, according to the care which has been used in handling the soil.

Originally this soil was covered with a heavy growth of longleaf pine, except near the Ocmulgee River, where shortleaf pine occurred. There was no underbrush, but a growth of wire grass. A larger relative proportion is at present under cultivation than of any other soil type in the county.

Short staple cotton and corn are the principal products grown on this type. Cotton, with careful cultivation, yields one-half bale and corn from 10 to 15 bushels per acre. Cowpeas, peanuts, and oats are also grown to some extent. One commercial peach orchard near Chester is partly located on this type. The greater part of the cultivated lands of Dodge County is of this soil, but considerable areas are yet found that have never been plowed. These are used chiefly as pasture and turpentine orchards.

The Norfolk sandy loam is well adapted to the production of peaches and other fruits. It is believed that it would prove a fair bright tobacco soil. Alfalfa has been grown successfully, and cowpeas and other forage crops do well, so that it is probable this would prove a good dairy soil. The manure which would be produced in the practice of dairying would be very beneficial if applied to the land. Sweet potatoes, Irish potatoes, strawberries, and other truck crops can also be produced.

Where under cultivation the Norfolk sandy loam is valued at from $10 to $15 an acre.

The following table shows the texture of both soil and subsoil of this type:

Mechanical analyses of Norfolk sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10746	7½ miles NE. of Rhine	Light sandy loam, 0 to 16 inches.	5.5	15.5	15.0	34.3	13.4	9.6	6.8
10744	6 miles W. of Dempsey	Light sandy loam, 0 to 16 inches.	5.8	16.9	15.0	30.1	14.2	9.0	8.9
10748	3 miles SE. of Eastman	Light sandy loam, 0 to 17 inches.	3.1	9.5	13.2	38.2	16.7	8.6	10.6
10747	Subsoil of 10746	Yellow sandy clay, 16 to 36 inches.	4.3	10.8	9.9	23.8	10.8	7.7	32.7
10745	Subsoil of 10744	Yellow sandy clay, 16 to 36 inches.	4.5	12.9	10.0	20.1	9.4	7.8	35.3
10749	Subsoil of 10748	Yellow sandy clay, 17 to 36 inches.	2.2	11.5	8.4	20.4	10.3	5.2	42.0

NORFOLK SAND.

In point of extent, at least, the Norfolk sand is the most important soil type in the county. It consists of a slightly loamy, grayish sand, medium to coarse in texture and from 4 to 10 inches deep, underlain by an incoherent yellow sand of similar texture, which extends to a depth varying from 30 inches to several feet. Before cultivation the line of demarcation between the soil and the subsoil is very distinct, occurring at the depth to which the roots of the wire grass have extended. A few years of cropping without the use of manures soon destroys this distinctiveness, and often almost entirely removes the organic matter, leaving only a very light gray, almost white sand for the surface soil, which gradually changes with depth to the typical yellow of the virgin land. This whiteness is very characteristic of the cultivated fields on much of this type.

In the more level areas a few small swampy places, locally known as "hammocks," from half an acre to 3 acres in extent, are seen. Immediately around these the sand is finer, and in the wettest parts the subsoil is a sticky sand. Aside from this the soil in most of the flatter areas is very uniform, and usually more than 3 feet deep. The sand on the slopes is somewhat more variable, in places containing some fine sand and in others a relatively large amount of coarse sand and gravel. The areas of coarsest sand have been mapped as Norfolk coarse sand.

Southeast of Rhine there is an area of very flat, poorly drained land, through which Cypress Creek passes on its way to the river. The soil here contains a greater amount of organic matter than the typical Norfolk sand, and the subsoil has an admixture of yellow clay, while at 30 inches a sticky sand is found. Another phase is found in which the subsoil is red and contains an admixture of red clay. Small areas of this latter phase are found in several places along the river. Both these phases are somewhat more productive than the typical Norfolk sand, the red phase being more so than the other. On the flatter areas around the Little Ocmulgee River and other streams the native forest growth is scrub and post oak, with now and then some longleaf pine; on the red sandy phase it is shortleaf pine, but other areas have the longleaf pine. Wire grass grows on all the phases.

The Norfolk sand is found to a greater or less extent along all the streams in the county. Beginning near the center of the northwestern boundary line, a strip some 2 miles wide is found on the Little Ocmulgee River. This increases in width to 4 or 5 miles where Waltons Creek joins the river, about 7 miles north of Eastman, and maintains this width until near Godwinsville, where the sand areas bordering this creek and Sugar Creek nearly join, and then are almost continuous to the southeastern county line. Another large area is found on the tributaries of the Ocmulgee River, southwest and northwest of Rhine.

The Norfolk sand occurs both on the steeper hillsides and in flat areas near streams, and almost every stream is bordered by slopes of this type, sometimes with, but often without, intervening areas of Meadow. It is common to find the Norfolk sand on the hillsides grading into the heavier Norfolk sandy loam on the summits, but where the streams are very numerous, the Norfolk sand may extend from one to another entirely across the hills.

The texture of this soil is such that even on the flattest areas drainage is excessive, and plants suffer from lack of moisture. Most of the "hammocks" dry out during the summer, and even in winter a few rods from their margins the soil is as dry as anywhere. Owing to its position the flat area near Rhine is rather poorly drained, and can not be plowed early in the season, but crops are rarely injured from an excess of moisture during the growing season.

The Norfolk sand along the hillsides is composed of the coarser particles which have been left under conditions of greater erosion than has operated in areas where the Norfolk sandy loam occurs. Thus most of the clay and other finer particles as originally deposited have been removed and little but the sand left. The flatter areas have been built up by stream action at some time subsequent to the uplift of the country, assisted to some extent by wash from surrounding types, and in such areas the proportion of fine material is slightly greater.

Cotton and corn are the chief crops. Cotton yields about one-third bale per acre on the red phase and one-sixth to one-fourth bale on the other areas. The yield of corn ranges from 8 to 12 bushels. A few watermelons are grown for local use and some have been shipped to outside markets. A large proportion of the area of this soil type—a greater proportion than in the case of the Norfolk sandy loam—is yet in a wild state and is valued chiefly for wire-grass pasture and for the available timber and turpentine.

The type is preeminently adapted to the growing of early truck, and it would seem that watermelons and cantaloupes should prove profitable. With better transportation facilities these and other truck crops will doubtless be the chief interests on this soil. The type now sells at from $4 to $10 an acre.

The following table shows the texture of both soil and subsoil of this type:

Mechanical analyses of Norfolk sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10739	2 miles NW. of Rhine....	Gray loamy sand, 0 to 10 inches.	6.9	22.7	16.5	27.7	13.8	9.0	3.4
10741	7 miles N. of Eastman...	Medium to coarse sand, 0 to 36 inches.	9.1	19.9	14.1	30.0	15.2	7.3	4.2
10743	8 miles NE. of Rhine.....	Gray sand, 0 to 36 inches.	7.6	20.5	16.3	29.7	12.8	7.5	5.0
10740	Subsoil of 10739...........	Yellow loamy sand, 10 to 36 inches.	8.3	21.1	15.4	28.4	14.0	7.6	5.1

NORFOLK COARSE SAND.

The Norfolk coarse sand is a coarse, grayish sand, carrying from 2 to 5 per cent of rounded, light-colored quartz gravel, from one-fourth to 1 inch in diameter. This material extends to a depth of from 24 to 36 inches, and is underlain by a yellowish gravelly clay, or gravelly, sticky sand. This soil is locally termed "white pebble land," from the color of the quartz pebbles. As compared with the Norfolk sand, the Norfolk coarse sand contains a higher proportion of fine gravel and the coarsest grades of sand. The native vegetation is longleaf pine and wire grass.

The largest areas of this soil type are found around the heads of some of the smaller streams which flow into the Ocmulgee River. Smaller areas are seen near Gresston and Empire, in the northwestern part of the county, while other scattered areas occur in the northeastern part.

The Norfolk coarse sand is the most hilly soil in Dodge County, and much of the surface is greatly broken. No large streams cross it, but it is found on the edge of the divides, and the smaller streams have cut many V-shaped channels through it, from 30 to 60 feet deep, so that the areas are formed of a succession of hills and valleys. Around the heads of these streams the soil changes gradually into the Norfolk sandy loam, while toward the larger streams it passes into the Norfolk sand.

The Norfolk coarse sand is excessively drained, and crops suffer from lack of moisture. Owing to its porous nature, and the heavy character of the particles, it does not wash so severely as the other soils of the area.

Cotton and corn are the chief products grown on this type of soil. Cotton yields from one-sixth to one-fifth bale per acre, and corn in proportion. But a small part of the area of this soil is at present cultivated. It is adapted to much the same crops as the Norfolk sand, but gives smaller yields than that type.

The following table shows the texture of the fine earth of both soil and subsoil of this type:

Mechanical analyses of Norfolk coarse sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10738	6 miles S. of Eastman....	Gray coarse sand, 0 to 36 inches.	11.1	24.8	17.2	28.9	9.6	5.9	2.6
10736	1½ miles SE. of Dubois....	Gray coarse sand, 0 to 24 inches.	25.0	30.9	13.0	15.6	6.1	5.7	3.5
10737	Subsoil of 10736............	Coarse gravelly clay, 24 to 36 inches.	24.7	25.3	9.0	8.1	2.9	4.3	25.3

MEADOW.

The term Meadow is used in this area to cover the bottom lands that are subject to overflow during winter and other rainy seasons, and which, unless artificially drained or diked, are for a great part of the year too wet to produce good crops. Such land is locally called "swamp."

There are three more or less distinct phases of Meadow in Dodge County. One consists of the narrow bottoms found along the smaller streams. Here the soil is a dark, sometimes mucky, sand 3 to 6 inches deep, underlain by gray sand, and this at varying depths by sticky yellowish sand. Such areas are covered with a thick growth of bay, gum, cypress, and other water-loving trees, with an undergrowth of bushes and cane. They rarely exceed half a mile in width, and the average width is about one-fourth mile. In the wider areas are found spots of clay, which may be only a few inches deep, or may extend without change to a depth of 3 or 4 feet. There are also a few shallow deposits of muck, which is sometimes used as manure on the lighter soils of the uplands.

The second and third phases are found on the bottoms along the Ocmulgee River. As is common with southern rivers, this one is characterized by an inner slough more or less well developed, with higher, dryer land near the river. In this sloughlike depression is found a soil which is somewhat distinct from that seen nearer the river, yet both are covered by the same character of vegetation. Here the soil is a dark-brown silty or very fine sandy loam, rich in organic matter, and underlain by a subsoil of yellow or drab silty clay, which sometimes becomes heavier in texture in lower depths. As the stream is approached the sand content increases in both soil and subsoil, and the organic matter decreases, so that near the stream is found a light-brown sandy or fine sandy loam underlain by yellowish sandy clay or clay loam. The whole of these two phases is covered with a thick growth of longleaf and shortleaf pine, gum, and cypress, with an impenetrable undergrowth of bushes and vines. The growth which particularly distinguishes these areas from all other soils in the county is the scrub palmetto.

The areas of Meadow are always nearly level, with the exception of those occupying the sloughs, and are of necessity poorly drained. It is impossible to produce crops on this type without first draining it, or in some cases, as along the Ocmulgee River, both diking and draining it.

The Meadow has resulted from stream deposition, assisted in some cases, in the narrower areas, by the wash from bordering slopes and uplands.

None of the Meadow is at present cultivated. The canebrakes are used to some extent for pasture, and sometimes the cane is cut. Some of the Ocmulgee bottoms were once cultivated, but their cultivation has been abandoned. The clearing and draining of large areas would greatly improve the healthfulness of the bottom lands, and when this is done they will undoubtedly be found the best soil in the county for corn, grass, and sugar cane. Cotton should also do well here if not attacked by the rust.

AGRICULTURAL METHODS.

Nearly all the implements used in this county are of the one-horse type, although the two-horse disk harrow and disk plow are used to some extent. Many fields are so full of stumps as to prohibit absolutely the use of two-horse machinery.

The rotation of crops is not very systematically practiced. The best farmers look upon cotton for one or two years, followed by corn, with cowpeas sown between the rows at the time of last cultivation, as the rotation best suited to their conditions.

Better farm animals, and more of them, the growing of more leguminous crops, such as cowpeas, and the careful husbanding and use of stable manure would not only lessen the expenditures for fertilizer and give better profits, but would also build up the productiveness of the land, instead of barely maintaining it, as is now the case at best. Deeper plowing would also help to improve the land, especially where it is of the heavier types of soil.

In 1900 commercial fertilizers to the value of $55,310 were applied to the land in Dodge County. The same year there was expended for all labor on farms the sum of $56,450. Various kinds of artificial fertilizer are used. These are applied at the rate of 200 or 300 pounds to the acre for cotton, and somewhat less for corn. In the majority of cases some complete fertilizer is used. Cotton-seed meal and acid phosphate are also much employed. It would seem that the use of the meal should be more common, as it adds organic matter to the soil, in addition to mineral elements.

Some farmers make a practice of buying new cotton seed every four or five years. This seems to give fair results, but it is believed the necessity of buying would not exist if the planter would exercise more care in selecting seed of his own growing. There seems to be greater need of better seed corn than of better seed cotton.[a]

Terracing and contour cultivation are very generally practiced, and are looked upon as necessary to prevent damage to the fields from washing.

AGRICULTURAL CONDITIONS.

Nearly one-third of the land in Dodge County is classed by the tax collector as "wild land"—a term used to indicate the river and stream bottoms and other areas that have never been cultivated. The greater part of such areas lies in the southern and southwestern parts of the county, near the Ocmulgee River. Considerable areas of the Norfolk sand along the Little Ocmulgee River and Sugar Creek are included in this classification, while extensive areas of the Norfolk sandy loam in some parts of the county are yet unimproved. In the eastern and northern parts of the county the greater proportion of all types of soil has been cleared of forest and is under cultivation.

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[a] See Yearbook, 1902, U. S. Dept. of Agr., pp. 365 and 539, for discussion of selecting seed cotton and seed corn.

The wild lands are assessed at $1 or $2 an acre, and other lands at from $3 to $5, about one-third of their average value. The best improved lands in the county would bring probably $10 or $15 an acre.

It is thus seen that the area is one of relatively low land values. The improvements on the farms, also, are generally inexpensive. The total value of all farm buildings in the county, according to the Twelfth Census, was $288,030, and a conservative estimate of the value of the buildings on the average farm would place it between $250 and $500.

Much of the county has the appearance of a new, undeveloped country, and in general its appearance indicates at best a moderate degree of prosperity.

The farmhouses are small, usually containing but four or five rooms, and outside the towns very few are more than one story in height. As a rule they are unpainted, while the cabins of the poorer class are built of rough boards, with stick and mud chimneys. The best houses are almost invariably found on the Norfolk sandy loam, and judging from these the most prosperous communities are situated along the railroad in the northwestern part of the county, where the proportion of this type of soil is greatest.

Cotton is the staple product of Dodge County, and, as in other parts of the South, agriculture suffers from the too exclusive culture of this crop. The lands are for the most part light and sandy, and not at all suited to the improvident methods in use, under which little or no attention is given to the maintenance of productiveness by crop rotation. Use is rarely made of stable manure or green manuring crops. Cotton so monopolizes the efforts of many of the planters that they do not even produce the necessaries that could easily be grown on the farm.

The credit system is generally practiced. Supplies of all kinds, fertilizers, implements, etc., are bought to be paid for when the cotton crop is made. To cover losses and interest the merchant charges a high price for his goods, so that these debts usually absorb a great part of the income from cotton, and the farmer starts the year at best free from debt, but with no surplus capital with which to carry on the operations of the succeeding year. The more intelligent planters realize that the system is unfortunate for the community, and express the situation by saying, "We are always one year behind time."

Aside from the "wild lands," there is more or less waste land on every farm, and at the present time very little more than one-third of the land in farms is actually under cultivation. Of this, probably one-half is cultivated by the owners themselves; the remainder is handled under three systems of renting, viz, "cropping," share renting, and cash renting. Tenants of the first class are the most numerous. Under this system the landlord furnishes the land, mules, implements, and half the fertilizer, and receives half the cotton, after paying half the expense of ginning. A large proportion of the negroes work as "croppers." The profits of the landlord are not large, as he is bound, by a moral responsibility at least, to look after his tenants in case of sickness and to tide them over seasons of bad crops. On many farms operated in this way are stores from which the tenants obtain their supplies. These are seen also on farms rented in other ways.

When land is rented on "shares," the landlord provides only the land, and the tenant supplies the mules, implements, etc., the former receiving a stated amount of lint cotton, usually 1,000 pounds per "one-horse" farm (30 to 40 acres). These two systems are seen side by side, often both on the same plantation, and one-third of the land is rented under one or the other plan.

About 16 per cent of the cultivated area is rented for a definite cash rental, usually from $1 to $2 an acre. White tenants form the majority under this system. Wild lands are not fenced, and are used for turpentine orchards and as pasture.

There were 1,567 farms in the 230,000 acres in the county classed by the Twelfth Census as improved land, which would make the average size of farms about 150 acres. It should be remembered, however, that the census classes every holding of a tenant as a farm, and the average amount of land owned by the individual is much larger. Several men in the county own more than 1,000 acres each. As approximately only one-third of the land in the county is actually under cultivation, the average amount of tilled land per farm is much less than 150 acres, and is really nearer 50 acres. One and two horse farms are most common (30 to 80 acres), and a two-horse farm is looked upon as above the average. Recent sales of land have usually been of single "lots" of 202½ acres, and it is probable that in time the average farm will be nearer this size.

Both white and colored labor is employed in this area, but the negroes are in the majority. Unskilled farm labor receives from $9 to $15 a month. Cotton is picked by "task," the average rate being 50 cents per 100 pounds of seed cotton. This labor is performed largely by the negroes, and all members of the family take part. For growing cotton and corn such labor is considered fairly efficient. As a rule, the negroes prefer "cropping" to working for wages, as it gives them more independence, so that at times it is difficult to obtain sufficient help. In the turpentine business the wages are higher, as it requires some knowledge and skill, but that industry is nearing its end.

As already stated, cotton and corn are the principal products of this area. In 1899 there were grown 29,244 acres of cotton, which produced 10,253 bales, and 33,627 acres of corn, which yielded 274,210 bushels. While the acreage of corn is the greater, as a source of income cotton is vastly more important. It is the chief and almost the only money crop. Very little more corn is grown than is necessary for home consumption. Other products are oat hay, peavine hay, sweet potatoes, Irish potatoes, watermelons, sugar cane for the manufacture of sirup, and orchard products. There is one peach orchard near Chester containing 34,000 trees, and a smaller one near Chauncey, where this fruit is successfully grown on a commercial scale. The Norfolk sandy loam is well adapted to peaches, and if means are used to control the scale, which has been very destructive in the past, it is probable that this industry will be found very profitable. There is only one dairy farm in the county. Most of the farmers pay little attention to producing milk and butter. The Norfolk sandy loam is well adapted to dairying. Alfalfa could probably be grown on it, and the long growing season gives opportunity to harvest at least two forage crops a year on the same land. Hence it would seem that dairying is worthy of more attention.

The live stock of the county, generally speaking, is of inferior grades. A good class of animals is as necessary as correct feeding in producing good beef or good butter and in doing it profitably, and the efforts of the progressive farmers should be made with a view to improving the conditions in this respect.

The production of sugar cane for the manufacture of sirup on a commercial scale is one of the possibilities of this area. At present it is made chiefly at home in kettles. Sugar cane grows well on all lands in the county, but does best on the Norfolk sandy loam. If drained, the bottoms would doubtless produce the heaviest yields, but the sirup could not compete in quality with the product of the upland soils.

The newness of this section has prevented, to a great extent, the working out of the adaptation of soils to crops, cotton and corn being grown indiscriminately on all soils. It is generally recognized that the Norfolk sandy loam is a stronger, more productive soil than the Norfolk sand, as is shown by the difference in the selling price of cultivated areas of these types. The Norfolk sandy loam brings from $10 to $15 an acre, and the Norfolk sand from $5 to $10 an acre. The latter type is looked upon as a good soil for watermelons, but few have ever been grown except for the local market. This soil is also well adapted to cantaloupes and early truck. There is such a large area of this type in Dodge County that it would be possible to go into this business on a large scale, and the subject is worthy of the attention of farmers and landowners.

Three railroads cross this area. A branch of the Southern system, running from Atlanta to Brunswick, enters the county at Empire and passes through Eastman, near the center of the county. The Wrightsville and Tennille Railroad crosses the northern part of the county and the Seaboard Air Line the southern part. Railroad facilities are not all that could be desired, as there are many points in the county more than 9 miles from any railroad, and over deep, sandy roads at that. A line from Dublin to Abbeville has been projected. This would cross the county from northeast to southwest and help develop a section as yet untouched by railroads. The Ocmulgee River is navigable from Hawkinsville on through the Altamaha to the sea, but owing to swampy bottoms and the absence of a shipping point very little of the products of Dodge County is shipped by this route.

Dirt roads traverse the area in every direction. Private or "settlement" roads reach points not touched by public roads, and in many instances are as well cared for as the latter. The great amount of sand in the county, so distributed that it is hardly possible to go anywhere without encountering areas of it, materially reduces the load which can be hauled.

Eastman is the largest town in the county, having a population in 1900 of 1,235, and most of the business of the county is done there. It has one oil mill and two cotton warehouses. Rhine, Milan, Chauncey, Younker, Chester, Empire, and other points also buy cotton and cotton seed. A small proportion of this crop is marketed outside the county. All these places have gins, and most of the cotton is ginned where sold.

SOIL SURVEY OF THE BAINBRIDGE AREA, GEORGIA.

By ELMER O. FIPPIN and J. A. DRAKE.

LOCATION AND BOUNDARIES OF THE AREA.

Decatur County is situated in the extreme southwestern part of Georgia. It is separated from Alabama and Florida on the west by the Chattahoochee River, and borders the latter State on the south. The Flint River flows across the county from the northeastern part

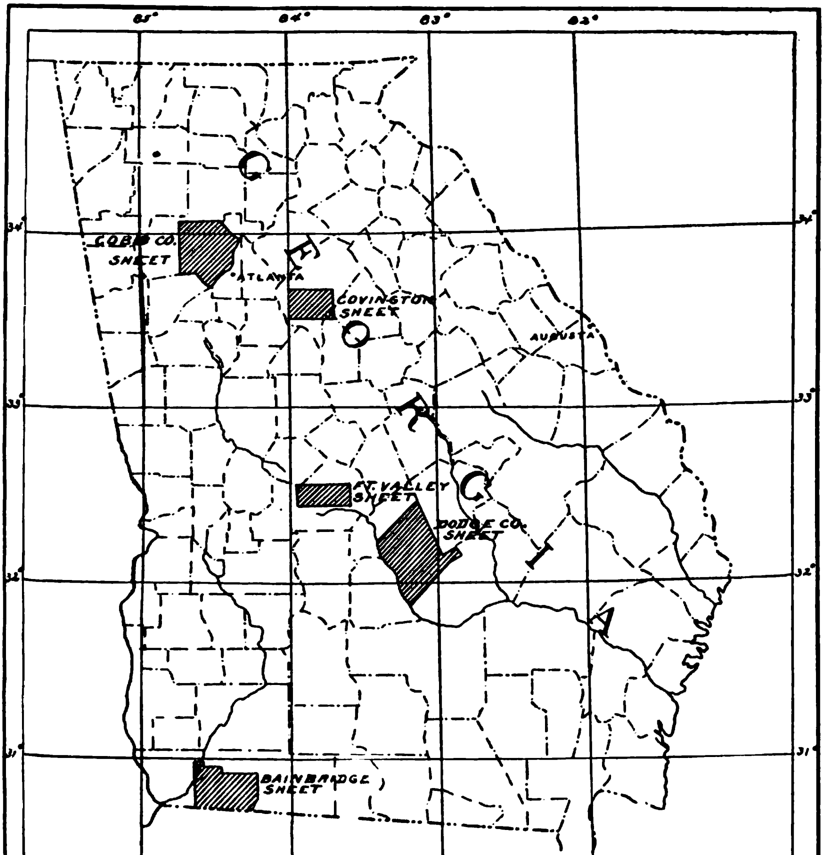

FIG. 9.—Sketch map showing location of the Bainbridge area, Georgia.

to the southwest corner, where it joins the Chattahoochee River to form the Apalachicola, which empties into the Gulf of Mexico at Apalachicola, about 90 miles farther south. The Ocklocknee River forms about 6 miles of the southeastern boundary of the county, and empties into Apalachee Bay.

The area surveyed comprises 364 square miles in the southeastern part of Decatur County. It joins Thomas County on the east and Gadsden County, Fla., on the south.

Bainbridge, the largest town in the area, with a population of about 3,000, is located at the head of navigation on the Flint River, which flows a distance of 10 miles in the northwest corner of the area. Whigham and Climax are small towns on the railroad in the northern part of the area, and Cairo is an active business town of larger size a half mile east of the area, on the same line of railroad.

The present survey connects with the survey of Gadsden County, Fla., made in 1903, and includes the remainder of the lands in this region on which Sumatra tobacco has been successfully grown under shade. In physical features, soil conditions, climate, and agricultural development the two areas are very similar. For this reason, instead of restating the facts, and to assist in a clearer understanding of the conditions in the region as a whole, frequent reference will be made in this report to the earlier report, which forms a part of Field Operations of the Bureau of Soils, 1903.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The cultivation of crops in this area has been in progress for a century. In common with a large part of the surrounding country, this region was settled by people who came mostly from Virginia and the Carolinas. The tracts along the streams, commonly known as "hammock land," of a distinctly sandy texture, with a large content of decaying organic matter, were the first to be cultivated, and continued to be used almost exclusively for farming purposes until 1865, or even later. In such areas the timber is a mixed growth of pine and hardwood. Shortleaf pine, oak, and hickory are the most common species, and longleaf pine and sweet gum are of frequent occurrence. The chief crops grown were cotton, tobacco, sugar cane, and corn. For the production of the best tobacco, which was a wrapper type, fresh hammock land was considered necessary. Hence the location of the crop was frequently changed to newly cleared lands. The open forests of longleaf pine that cover the low, flat divides between the streams remained uncleared, and were considered of no agricultural value.

Within the last forty years there has been a radical change in the treatment of these open forest lands, and they are now the most extensively cultivated and command the highest prices of any in the area. The "hammock land" has depreciated relatively in value. Much of it along the streams is still cultivated, but owing to the uneven surface and poor drainage of some areas, and to the fact that the soil is not very durable, its permanent improvement has not kept pace with that of other soil types.

As a result of the changed conditions after the civil war, the farms became smaller and consequently more numerous. There has been some change also in the kind of crops grown and their relative extent. Instead of making cotton the principal crop, such supply crops as corn, sugar cane, sweet and Irish potatoes, peanuts, and other legumes are grown. The farmers, by diversifying their crops, are enabled to produce more of the necessaries of life and buy less from abroad. Cotton and sugar cane are grown as money crops. Tobacco, after many fluctuations, is now the leading money crop on the larger and better managed farms. The history of the changes in tobacco production has been given somewhat fully in the Gadsden County report, and will not be repeated here. The Sumatra leaf, which was introduced twelve or fourteen years ago, and which began to be grown under artificial shade of cloth or slats in 1895, is increasing in production. In the Bainbridge area the lath construction has been substituted for nearly all of the cloth shade. The production of all crops except cotton is increasing, leguminous crops are receiving more attention, and their production is arousing more interest in the raising of live stock.

CLIMATE.

The normal annual temperature of the region is about 66.5° F., and the annual precipitation averages 54 inches. Freezing temperatures occasionally occur during the winter months, and sometimes there are light snowfalls, but neither of these conditions is of long duration and is soon followed by mild temperatures and light frosts at night. Fogs frequently occur in the morning, but generally disappear by 9 or 10 o'clock, and the proportion of days with cloudy or overcast sky is relatively small. The precipitation during the growing season of seven months—from March to September, inclusive—is 37 inches.

More detailed information is afforded by the following table, taken from the records of the Weather Bureau stations at Bainbridge and Thomasville.

Normal monthly and annual temperature and precipitation.

Month.	Bainbridge.		Thomasville.		Month.	Bainbridge.		Thomasville.	
	Temperature.	Precipitation.	Temperature.	Precipitation.		Temperature.	Precipitation.	Temperature.	Precipitation.
	° F.	*Inches.*	*° F.*	*Inches.*		*° F.*	*Inches.*	*° F.*	*Inches.*
January	49.2	0.87	51.9	3.64	August	81.1	6.12	80.7	6.33
February	49.6	7.57	52.5	4.88	September	77.1	3.16	77.1	4.44
March	60.8	11.85	60.6	4.51	October	66.9	1.96	68.2	3.41
April	65.1	1.01	67.5	3.74	November	56.9	1.55	58.9	2.73
May	74.4	3.40	74.1	3.92	December	52.0	4.44	52.3	4.26
June	81.2	4.85	79.7	5.40	Year	66.4	53.42	67.1	54.15
July	82.0	6.64	81.5	6.89					

PHYSIOGRAPHY AND GEOLOGY.

The area surveyed is divided into two parts by a low, broad, flat watershed, the crest of which extends from southwest to northeast through Fowlstown and Climax and separates the waters of the Ocklocknee River and its tributaries from the basin of the Flint River.

About one-third of the area is north of this divide. The surface there is usually very gently rolling or flat, but in a few places the elevations are greater and the slope more abrupt. From 2 to 4 miles north of the crest of the divide the surface descends by a rather steep slope a distance of from 20 to 50 feet, below which begins a region with a somewhat billowy surface that broadens toward the north and extends beyond the Flint River. The Flint River in this part of the area is peculiar in that it does not receive any surface tributaries of any kind and has no border of low wet land to mark its flood level. In the adjacent country occur many small depressions, into which short, broad ravines lead, and during rains the water runs to these depressions, where it sinks into the sandy bottom or disappears in a crevice. The movement of the water is not usually sufficiently rapid to erode a channel. The country where this peculiar drainage system is found has an extent of about 35 square miles.

The region between the country just described and the escarpment already mentioned has another distinctive system of drainage. A number of small streams begin on the divide, where for a short distance they have rather steep walls, but soon pass out on a flat sand plain, over which they wander and finally flow into small lakes or ponds from which the water is drained below the surface. Several of these lakes are connected by streams, and in times of much rainfall the level of the water may be raised so that the direction of flow is reversed. The lakes are shallow and flat and may increase greatly in extent in times of heavy rainfall. The final outlet of these "sinks" is not known.

South of the divide there are a half dozen large creeks that have a southerly course. Three of these pass into the eastern part of

Gadsden County, Fla., where they form the Little River. Many smaller streams empty into these creeks, and narrow areas of low, wet, swampy land border all their channels. The slope usually descends sharply from the upland to the swamp, and thus forms a rolling and hilly surface. This feature is most accentuated in the southern part of the area along the Florida line. The slopes become more gentle toward the north and the minor divides finally unite around the heads of the streams to form the flat, open country of the main watershed. The largest creeks in the southern part of the county are Willocoochee, Attapulgus, Swamp, Bryants Mill, and Tired creeks. They are of the dendric type, and divide and subdivide until they are mere threads of water with a series of small springs as their source.

The largest timber, as well as the greatest variety of species, is found along these streams and in the swampy bottoms. It consists of both pine and hardwood. Oak, hickory, walnut, sweet and sour gum, magnolia, bay, dogwood, and liveoak are the principal hardwood species. In the most swampy places in the stream bottoms and on the divides the cypress occurs. Away from the streams the timber is almost exclusively longleaf pine on the heavier soils and a species of scrub oak on very sandy soils. These forests are open and the trees branch high. They cover a large part of the surface of the county.

The material forming the surface of the country to depths of several hundred feet consists of marine sediments, and belongs to the Eocene geological period, formerly known in part as the Lafayette. It is composed of sands and clays forming strata varying in thickness and unevenly stained red, orange, or yellow by compounds of iron. In the northern part of the area, particularly on the west side of the Flint River, a ledge of limestone is exposed. The clay, with few exceptions, contains a very large proportion of sand of medium and fine grades. Along the creeks in the southwestern part of the area deposits of fuller's earth outcrop frequently, and deposits containing phosphate are reported in one or two places.

The materials forming the present soil covering of the region appear to be shore and shallow sea deposits (McGee).

SOILS.

The Ocklocknee River and the large creeks in the southern part of the area are bordered by deep sand. North of the sand and extending about 3 miles north of the crest of the main watershed a sandy clay occurs within 2 or 3 feet of the surface. This broad area has a northeast and southwest trend. On the southern side the color is chiefly red, and a similar color prevails in smaller areas on the northern side, but the broad central divide is composed mainly of yellow sandy clay. Northwest of this broad tract of sandy clay subsoil the deep sand again occurs, extending over the remainder of the area, its continuity broken only by limited tracts of heavier soils. All the types have a very sandy top soil. The extent of the different types is given in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Norfolk fine sandy loam	93,248	40.1	Meadow	14,336	6.2
Orangeburg fine sandy loam.	36,480	15.7	Gadsden sand	7,488	3.2
Norfolk sand	29,696	12.8	Portsmouth sand	3,456	1.4
Norfolk sandy loam	24,576	10.6	Ocklocknee clay	832	.3
Orangeburg sand	22,592	9.7	Total	232,704	

ORANGEBURG FINE SANDY LOAM.[a]

The soil of the Orangeburg fine sandy loam is a brown fine sandy loam or fine sand, or a somewhat lighter-textured gray fine sandy loam. The sand is largely of fine and very fine grades, except in the northwestern part of the area around Bainbridge, where it is coarser. The average depth is about 10 inches. The subsoil is a dark-red sandy clay, the sand here also being of the fine and very fine grades. The type is developed chiefly in the southern part of the area along Attapulgus Creek and on the bluffs a few miles back from Ocklocknee River. Other important bodies occur from 4 to 6 miles south of Bainbridge and a few miles east of Whigham along Tired Creek in the eastern part of the area. A few smaller bodies are found at other points.

The Orangeburg fine sandy loam forms the most hilly portion of the area and sometimes has rather steep slopes. The hills are comparatively high, with rounded outlines, and are so situated that good drainage is established. The type never occurs in very wet or springy places. The most hilly portions are along Attapulgus Creek and its tributaries.

The slope of the surface usually insures good drainage. The soil absorbs water quickly, but does not permit it to pass quickly into the subsoil. The latter also holds moisture well, and yet does not become very wet. Where the slope is such that the surface water drains off rapidly both the soil and subsoil are quickly eroded away, and when a considerable depth is attained the process of erosion is difficult to stop, because the seepage of water from the soil at the base renders the material loose and caving rapidly enlarges the channel. Brush affords one of the most effective means of stopping this washing. The surface washing is commonly kept in check by contour cultivation and by sidehill ditches.

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[a] The same soil in the Gadsden County survey across the line in Florida was mapped as Orangeburg sandy loam.

The materials making up this soil are of sedimentary origin, and form a stratum from 5 to 30 feet in thickness that usually rests on sand. The dark-red color is due to the presence of iron, which has been concentrated in some parts of the soil to such an extent as to form dark-brown concretionary pebbles. These are unevenly distributed, but are very abundant over limited areas of the type.

This soil type is the best in the area for the production of cotton and filler tobacco. The yield of cotton without fertilizer is about one-half bale per acre, and with moderate fertilization 700 pounds of tobacco per acre can be produced. It is not considered a good soil for the growing of Sumatra leaf under shade, because the product is heavy and dark colored and the burn is often inferior.

Sugar cane on this soil type produces from 12 to 23 barrels of sirup per acre, but the quality and flavor are not the best. The yield of corn is from 8 to 12 bushels per acre, and of oats about the same.

The heavier areas of the type constitute the best cotton land, and the lighter portions are the best for producing filler tobacco. The Orangeburg fine sandy loam has a good basis for increasing its productivity, and only needs to be enriched in organic matter.

The following table shows the mechanical analyses of typical samples of this soil:

Mechanical analyses of Orangeburg fine sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10721	7 miles SE. of Whigham.	Brown sandy loam, 0 to 10 inches.	0.8	3.7	8.3	45.2	24.9	7.6	9.5
10719	3 miles SE. of Attapulgus.	Medium sandy loam, 0 to 10 inches.	1.9	7.9	10.6	37.2	25.3	7.1	9.9
10723	4¼ miles S. of Bainbridge.	Brown sandy loam, 0 to 9 inches.	1.7	5.5	6.9	37.0	33.3	4.6	11.0
10722	Subsoil of 10721	Red sandy clay, 10 to 36 inches.	1.0	2.6	5.8	35.8	20.5	5.8	28.5
10720	Subsoil of 10719	Sticky, red sandy clay, 10 to 36 inches.	.3	2.0	3.3	37.6	18.4	6.1	32.2
10724	Subsoil of 10723	Red sandy clay, 9 to 36 inches.	1.3	4.2	5.2	25.7	24.1	4.7	34.8

ORANGEBURG SAND.

The Orangeburg sand is a dark-gray loamy sand, having a depth of 7 inches, underlain by a rust-colored sand, about 13 inches in thickness, which grades into a dark-red sandy clay. The distinction between this type and the Orangeburg fine sandy loam is in the greater depth to the red clay. In the southern and eastern parts of the county the fine and very fine grades of sand predominate, but to the northwest the proportion of medium and coarse grades is greater. Where this type occurs along the Flint River above Bainbridge the subsoil is heavy, impervious light-orange clay, with a small content of sand, and distinctly heavier than the normal subsoil of this type.

The largest bodies of the Orangeburg sand occur around Bainbridge. Tracts less than a square mile in extent are found frequently on the main divide and in the southern part, where the red clay is most prominent. The surface is rolling, but less hilly than that of the Orangeburg fine sandy loam. Many of the areas have an even, moderately sloping surface. This type of soil does not occur in wet positions and the drainage is good. The rapid movement of water over the surface causes serious erosion, but the considerable depth of sand tends to check the damage by quickly absorbing the water.

The material composing this soil type is of marine sedimentary origin. Concretionary pebbles of a dark-brown or yellowish color occur in this material, but are unevenly distributed and not usually very numerous.

All the crops commonly grown in the region are produced on this type of soil. Corn yields from 10 to 12 bushels per acre; sugar cane, from 8 to 15 barrels of sirup per acre, and cotton an average of one-third bale per acre. Not much tobacco is grown on this soil, its cultivation being confined to the southern part of the area, where, under shade and with heavy applications of fertilizer, about 1,000 pounds of wrapper leaf are produced per acre. The quality is good and the color light, but the burn is not as good as in tobacco grown on some of the other soils. The type is regarded as a fairly good tobacco soil in the southern part of the area, while in the northern part its adaptability to tobacco growing has not as yet been demonstrated.

The following table gives the mechanical analyses of typical samples of this soil:

Mechanical analyses of Orangeburg sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10717	5¼ miles SE. of Attapulgus.	Brown sand, 0 to 20 inches.	0.4	4.8	7.3	41.8	29.7	6.9	9.2
10715	1¼ miles S. of Bainbridge.	Brown sand, 0 to 18 inches.	4.5	18.5	17.0	28.2	12.6	7.8	11.9
10716	Subsoil of 10715	Red sandy clay, 18 to 36 inches.	7.0	19.1	13.2	21.8	8.7	6.0	24.1
10718	Subsoil of 10717	Dark-red sandy clay, 20 to 36 inches.	.5	3.7	5.4	32.2	25.0	4.7	28.1

NORFOLK FINE SANDY LOAM.

The Norfolk fine sandy loam to a depth of 7 inches is a gray fine sandy loam, usually darkened by the presence of organic matter. To a depth of 15 or 18 inches occurs a gray or yellow light sandy loam, which grades into a lemon-yellow sandy clay, becoming somewhat heavier as the depth increases. The sand is coarser in the northwestern part of the area than in the southern part, where it consists of fine grades. North of Bainbridge and for several miles north along the Flint River the subsoil clay is much heavier than in the true type, and of an orange or red mottled shade. It is quite impervious to water, and is closely related to the modification of the Orangeburg sand already discussed.

The Norfolk fine sandy loam is the most extensively developed type in the area, and occupies a strip from 6 to 10 miles in width on the main divide. It surrounds small bodies of other types, and detached bodies of it occur along the Flint River. The largest areas have an even surface, with a slight slope. Adjacent to streams the surface is more broken. Open forests of longleaf pine cover a large part of this type in the central part of the area, while in small shallow depressions, in which the accumulation of water forms permanent swamps, a growth of sour gum and cypress is found.

The material composing this type is of marine sedimentary origin and forms a stratum from 6 to 30 feet in thickness.

The yellow clay frequently appears as a narrow border along creeks and branches where the upland type is a red clay. The iron, which forms so prominent a mineral constituent of the material in general, has accumulated locally and formed yellow pebbles, which are unevenly distributed through the soil mass and in different parts of the area. They are very abundant around Climax for a distance of 2 or 3 miles, where the clay subsoil comes rather near the surface, and they are more common in the flat pine woods than in the more rolling region adjacent to the larger streams. They are frequently abundant over small areas in all parts of the type.

The crops grown and average yields per acre are about as follows: Cotton, one-third of a bale; corn and oats, from 12 to 20 bushels; sugar cane, from 12 to 20 barrels of sirup, and tobacco, from 600 to 800 pounds of filler leaf in the open and from 1,000 to 1,300 pounds of wrapper leaf under shade. These yields are secured by the use of fertilizer in varying quantities. The application in the case of sugar cane is from 800 to 2,000 pounds, and where tobacco is the crop, from 1,000 to 3,000 pounds per acre. From 100 to 400 pounds are used in growing the other crops. On this soil tobacco is grown only in the southern part of the area, where the streams are numerous, the production being limited almost entirely to areas along the creeks, which unite in Florida to form the Little River.

The Norfolk fine sandy loam more uniformly produces the best grades of wrapper-leaf tobacco than any other soil type in the area. There is seldom any defect in quality, color, or burn where the clay subsoil is a bright yellow, the sand from 12 to 18 inches deep, and iron pebbles are not abundant. It is the opinion of leaf buyers in the region that first-grade wrappers can not be produced on the large bodies of this type in the northern and central parts of the area, which are covered with open forests of pine. Whether this is so, however, has not been proved by actual tests under the best conditions. On the other hand, some fairly good crops have been obtained from small plots of this soil, as it occurs in those parts of the area.

The Norfolk fine sandy loam is also well adapted to sugar cane, and a uniformly good quality of sirup is produced. The yield is a little lower than on the red clay types, but the flavor and color of the sirup are better. This crop may be grown in any part of the type, although the moist areas are best. Peanuts, velvet beans, and other leguminous forage crops may be grown, and add greatly to the productivity of the land, especially if corn or oats is the crop to follow.

The following table gives the mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Norfolk fine sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10707	3 miles NE. of Attapulgus.	Dark gray sand, 0 to 16 inches.	2.7	8.2	9.0	39.4	26.5	5.9	8.3
10711	2 miles W. of Whigham.	Light sandy loam, 0 to 20 inches.	1.3	8.8	10.5	37.2	25.1	7.0	10.2
10709	¼ mile N. of Calvary.	Fine loamy sand, 0 to 15 inches.	.2	1.8	2.3	34.1	44.3	6.3	11.0
10712	Subsoil of 10711	Yellow sandy clay, 20 to 36 inches.	1.7	7.9	8.5	31.2	22.8	6.3	21.6
10710	Subsoil of 10709	Yellow sandy clay, 15 to 36 inches.	.1	1.1	1.5	26.2	34.7	5.9	30.6
10708	Subsoil of 10707	Yellow sandy clay, 16 to 36 inches.	1.7	5.8	5.9	29.1	19.9	5.5	31.9

NORFOLK SANDY LOAM.

The Norfolk sandy loam consists of 7 inches of a light-textured dark-gray sand, or sandy loam, underlain by a white or yellow sand, or light sandy loam, that grades into a yellow clayey sand, which at a depth of 30 inches passes into a yellow sandy clay. The type differs from the Norfolk fine sandy loam in its greater depth of sand.

The Norfolk sandy loam does not occupy large areas. Its main bodies are found 2 miles north of Climax and between that town and Whigham. Smaller tracts occur in the areas of yellow clay subsoil where the depth of sand is greater than 28 inches. The surface slopes gently or is almost flat. The areas north of Climax and one a few miles below Bainbridge are low and poorly drained. A number of small areas adjacent to streams are due to the accumulation of sand by erosion. These are usually well supplied with water, and crops may be grown on almost any of them during the greater part of the year.

Some tobacco of fair quality is produced, and good yields of corn are obtained from this type of soil, but it is too light for the successful growing of cotton or sugar cane, and is easily affected by drought. It is not naturally a productive soil, but being favorably situated with respect to moisture conditions some areas give very satisfactory yields of the crops grown.

The following table gives mechanical analyses of this soil:

Mechanical analyses of Norfolk sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10701	4 miles N. of Climax.	Sandy loam, 0 to 28 inches.	2.1	9.1	10.3	37.7	30.5	6.0	4.1
10699	4½ miles SE. of Attapulgus.	Gray to yellow sand, 0 to 32 inches.	3.3	8.9	7.6	38.0	29.4	6.4	6.2
10702	Subsoil of 10701	Yellow clayey sand, 28 to 36 inches.	2.7	9.0	9.9	37.1	27.6	4.7	8.9
10700	Subsoil of 10699	Yellow sandy clay	4.6	8.9	6.1	33.7	26.4	5.9	14.2

NORFOLK SAND.

The Norfolk sand is a loose dark-gray sand, 6 inches deep, underlain by 3 feet or more of loose white or rusty-yellow sand. Within 2 miles of Bainbridge the sand is coarse in texture and contains a very noticeable amount of fine gravel. In the southern part of the area the finer grades of sand are more prominent.

The largest body of the Norfolk sand occurs in the northwestern part of the area north and east of Bainbridge, where it forms broad stretches of country. The sand here is very loose and clean, and the timber consists of pine and oak. The two species usually occur in different positions, and much of the pine is large and thrifty. This is probably due to the presence of clay within from 4 to 6 feet of the surface. The oak growth is small and stunted, which indicates a soil of very deep sand. These relations between the vegetation and the depth to subsoil also hold where the type occurs in other parts of the area. Areas of the Norfolk sand of considerable extent are also found on the lower slopes along the Ocklocknee River, Swamp Creek, and the smaller streams, and small bodies are scattered through other parts of the area.

In general the surface of the Norfolk sand is gently rolling, or billowy, although there are some small tracts where the surface has a uniform, moderate slope. The loose, open character of the soil insures good drainage, except in a few small areas where it is surrounded by a rim of clay or where it receives the drainage from clay slopes at a higher level. The sand forming this type was laid down in shallow water over an uneven surface of clay, which explains its greatly varying thickness.

About one-third of the small bodies in the southern part of the area and along the Ocklocknee River, the most productive part of the type, is under cultivation. A smaller proportion of the large area in the northwestern part of the survey is cultivated. The crop yields are uniformly low and all crops are quickly affected by periods of drought. Along the streams corn yields from 10 to 15 bushels per acre, but on some of the upland areas only from 5 to 7 bushels are obtained. Cotton and sugar cane can not be profitably grown because of the low yields, although the quality of the sirup is very good. From 700 to 900 pounds of very good wrapper leaf is the usual yield of tobacco in a season of abundant rainfall, and with the application of the average quantity of fertilizer. The productivity of the virgin soil decreases rapidly under cultivation, and the type is so loose and porous that its crop-producing power can not be greatly increased. In crop adaptation this type is an early truck soil, for which purpose it is much used along the Atlantic seaboard.

The following table gives the mechanical analyses of typical samples of this soil:

Mechanical analyses of Norfolk sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10695	4½ miles SE. of Attapulgus.	Dark sand, 0 to 6 inches.	1.8	8.8	9.1	44.5	29.9	3.8	2.4
10697	3 miles S. of Bainbridge.	Brown sand, 0 to 12 inches.	2.8	11.1	10.8	36.2	33.1	4.0	2.7
10696	Subsoil of 10695	White sand, 6 to 36 inches.	1.2	7.2	8.1	43.4	33.2	4.5	2.1
10698	Subsoil of 10697	Medium to fine sand, 12 to 36 inches.	1.7	9.8	10.8	31.1	34.8	4.5	2.4

GADSDEN SAND.

The Gadsden sand is a dark sand 8 inches deep, underlain by a dark or orange sand of the finer grades. In the southern part of the area fine grades predominate.

The type is of limited extent and is distributed in small bodies throughout the area. It is distinguished from the Norfolk sand by its darker color, more loamy character, and by a less depth to the clay. The surface is gently rolling on the upland and more level and flat along streams. The lower areas have been formed largely from material washed down from the heavier types.

Corn yields from 10 to 20 bushels, and wrapper tobacco about 900 pounds per acre. The quality, color, and burn of the leaf are good. The yield of sirup ranges from 8 to 12 barrels per acre, and the quality is good. The cotton yields from one-half to 1 bale per acre. The type is well adapted to early truck, melons, and small fruits, and to light wrapper tobacco if the moisture supply is insured by irrigation. It is the best corn soil in the area.

The mechanical analyses of typical samples of the Gadsden sand are given in the following table:

Mechanical analyses of Gadsden sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10703	2 miles SE. of Calvary.	Dark sand, 0 to 16 inches.	0.9	5.2	7.7	48.6	28.8	4.1	4.7
10705	3 miles S. of Bainbridge.	Dark-brown sand, 0 to 14 inches.	3.3	17.6	18.5	32.8	17.5	4.3	5.8
10704	Subsoil of 10703	Brown sand, 16 to 36 inches.	.8	4.6	7.1	50.3	29.4	3.7	4.0
10706	Subsoil of 10705	Brown sand, 14 to 36 inches.	2.9	17.2	17.1	33.0	18.3	4.5	6.8

PORTSMOUTH SAND.

The Portsmouth sand is a dark or black sand, from 8 to 20 inches deep, underlain by a white sand saturated with water. The color of the top soil is due to the presence of a large amount of organic matter.

A few small bodies of this soil type occur at various points in the area, in low places along streams and around lakes or ponds, where the surface is flat and the drainage poor.

Probably all this type could be drained and cultivated. In a few places crops of sugar cane and corn are grown and the yields are large. The soil is too wet for peanuts, potatoes, or tobacco, but with proper drainage good crops of sugar cane, corn, and cotton can be grown.

The following table gives the mechanical analyses of this type:

Mechanical analyses of Portsmouth sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10693	2 miles SE. of Bainbridge.	Black sand, 0 to 10 inches.	7.2	27.2	23.8	29.6	6.8	3.0	2.4
10694	Subsoil of 10693	White sand, 10 to 36 inches	2.2	13.2	19.7	55.7	6.5	1.0	1.5

OCKLOCKNEE CLAY.

The soil of the Ocklocknee clay varies from a dark sandy loam to a heavy clay, from 5 to 12 inches deep, resting on a black or mottled red, stiff, plastic clay. The largest area of this soil lies 4 miles east of Bainbridge, and other small bodies occur in that vicinity and along the Flint River.

The surface is low, flat, and poorly drained, and this condition has probably assisted in the formation of the type. A stratum of fine-grained stiff clay outcrops at various points near the Flint River, and modifications of this material by water and plant remains have given it the characteristics of the type recognized. It is not cultivated, but if drained it would produce good cotton crops. Near Bainbridge the soil is used in the manufacture of brick.

The following table gives the mechanical analyses of this type:

Mechanical analyses of Ocklocknee clay.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10713	3¼ miles NE. of Bainbridge.	Clay, 0 to 10 inches	0.3	0.8	0.5	1.1	1.6	15.8	80.3
10714	Subsoil of 10713	Drab, stiff, impervious clay, 10 to 36 inches.	.5	1.5	1.2	4.2	4.2	14.1	73.6

MEADOW.

The streams in the area, except the Flint River, are fringed by low, wet, swampy soils of a variable character. The material consists of deposits from flood waters mixed with organic remains, and is usually a medium black sandy loam. It is cut by abandoned channels of the streams, in which are occasional pools of water. This land is so near the present level of the streams that it could not be permanently drained, but if it were cleared, and open ditches cut, grass might be grown with success on portions of it. None of this Meadow soil is at present under cultivation. The timber is a mixed growth of shortleaf pine, elm, magnolia, dogwood, bay, cypress, sweet and sour gum, and a few other species.

AGRICULTURAL METHODS.

The crops grown are cotton, corn, sugar cane, oats, tobacco (both wrapper and filler), Irish and sweet potatoes, velvet beans, cowpeas, peanuts, and small quantities of melons, small fruits, and truck. No systematic method of cropping is practiced. The land is plowed from 3 to 6 inches deep with a small, one-horse turning plow. Harrows, surface packers, or small-shovel cultivators are not used in the preparation of the seed bed. Most of the crops are planted in furrows made with the turning plow.

Fertilizers are applied to practically all crops, and the amounts used per acre range from 100 to 400 pounds for corn and cotton, from 1,000 to 2,000 pounds for sugar cane, and from 2,000 to 3,000 pounds for tobacco. The fertilizers consist of vegetable products like cotton-seed meal and hulls and mineral compounds. In addition to these some barnyard manure is used. The fertilizer or manure is generally applied in the spring before seeding, but for sugar cane and tobacco later applications are made during the growth of the crop. All fertilizers are distributed by hand or by means of a small tin tube 3½ feet in length.

Corn is dropped by hand, one grain at a time, from 4 to 6 feet apart in the row. Some farmers alternate the rows of corn with rows of peanuts, claiming that the same quantity of corn is produced by this method and that the peanut crop is a clear gain. The peanuts are not harvested in the usual way, but are left to be rooted out by hogs. This is a popular method of fattening hogs.

In the fall the leaves or blades of the corn while still green are gathered from the stalks, the ears of corn being left to mature. These are gathered with the shuck on. The stalks are not cut.

A one-horse seeder is sometimes used in planting cotton. About 2 bushels of seed are planted to the acre, and the plants are thinned to a distance of about 8 inches apart in the row. A little Sea Island cotton is grown in addition to the short staple variety.

Sugar cane is propagated by means of buds from the nodes of the stalks, which are preserved through the winter in windrows lightly covered with earth. In the spring the stalks are cut into 18-inch lengths and distributed along the furrow.

Oats are planted both in November and the latter part of January. The relative advantages of the two times of seeding are dependent upon the climatic conditions, which vary from season to season. The crop is cut and bundled, but not thrashed to any great extent. The crop is sometimes used for spring pasture, and should find greater favor for this purpose.

Tobacco is grown both in the open and under artificial shade. The former is chiefly a Havana filler, while the latter is exclusively a wrapper. The seed is sown in early spring—the last of February—in freshly cleared, moist land, rich in organic matter, and is covered with a loose meshed cloth. The plants are transplanted to the field by hand about the 1st of May, when from four to five leaves have developed. From forty-five to sixty days are required for the plants to mature. During this time constant care and cultivation are given. The leaves are primed separately and cured on lath stringers in specially constructed and well-ventilated barns. Following the curing process the leaves are fermented ("sweated") in large piles in a moderately heated warehouse in a moist atmosphere. The temperature of the bulk is limited to 140° F., and is controlled by reconstructing the piles ("rebulking"). The number of rebulkings is governed by the character of the crop.

The methods used in growing the other crops are less well defined. All crop rows are run on contours, and sidehill ridges are generally constructed on steep slopes. Both methods check erosion.

Very few cattle are fed for beef or dairy purposes. Inclosed pastures of cultivated grasses are not maintained, but the stock are permitted to graze in the forests and unplowed fields, where they feed on wild bunch grasses. The pasture range is burned over each spring to destroy the dry stems of the preceding year's growth, so as to render the young blades of grass accessible.

The soils generally are deficient in organic matter and in water-holding power. The depth of plowing should be gradually increased to 8 inches, especially on the heavier types of soil, and plant remains incorporated as rapidly as conditions will permit. It is the opinion of many farmers in the region that the plowing under of green-manuring crops in any considerable amount is injurious to and lessens the productivity of the soil for several seasons. Opposed to this idea is the practice of some of the most successful farmers in the same region, who have gradually deepened their soil and have found that the amount of plant remains that may be safely covered is increased proportionately. The presence of organic remains increases the water-holding power of the soil and hinders erosion. The light sandy soils should be packed by rolling and the surface made loose by shallow cultivating. On one or two farms the modern weeder is in use. This is an effective implement for creating a shallow surface mulch.

It is believed that the raising of live stock on a more extended scale would be practicable and profitable. The lack of forage and pasture may be largely supplied by legumes preserved in silos, and cultivated pastures of such crops as oats and rye, two or three crops of which might be grown each year, would also serve this purpose. The large amount of cotton-seed meal used as fertilizer would be little reduced in fertilizing value if passed through good dairy or beef cattle before being applied to the land, provided the manure were carefully preserved.

It seems probable that by careful management in the early stages alfalfa may be grown successfully on most of the well-drained areas of several of the finer textured soil types. Recently the Egyptian legume berseem has been recommended to the farmers in this region Both of these crops produce hay of fine quality, and are of thrifty growth in semiarid regions, yielding three or four good cuttings each season.

AGRICULTURAL CONDITIONS.

The farmers in this area can not be described as either wealthy or prosperous, but in financial condition and home comforts they will compare favorably with the farming classes of other regions in the Southern States. Improvement is taking place along many lines, and old ideas and methods are being abandoned for a more modern and progressive system. The good price of farm products during the last few years has been a large contributing factor in this progress. In addition the farmers have lately begun to diversify their crops and to raise the various products needed for home consumption. The acreage of cotton has been relatively reduced and that of other crops extended. Many farmers have abandoned cotton entirely. Free rural mail delivery has assisted in creating an interest in affairs beyond the limits of the county, and the farmers are learning more of the needs of the region as compared with other sections of the country. The attention of men of means in Northern States is being directed to the possibilities which this region offers. The result of all these factors has been a rapid increase in the price of farm lands in every part of the area. Not many years ago the maximum price of average farming land was not over $10 an acre, with the minimum below $3. Now good farming land several miles distant from a railroad or town will bring $5, while land favorably situated is valued at from $15 to $25 an acre, and in some instances even higher prices are demanded.

The farm buildings are usually small and cheaply constructed. Small one-room log cabins are common, and many of the better dwellings are two or three roomed structures of logs. Distributed throughout the area are a number of large dwellings of the style of forty years ago. Large, well-constructed buildings for live stock are not essential because of the mild winter climate, and the few crops stored require only a small space. The tobacco barns are well built, and the packing houses and warehouses of the large tobacco concerns are modern structures of brick and wood.

The live stock consists of horses, cattle, mules, sheep, hogs, and goats. All of these are of mixed strains and are small in size. Near Bainbridge several herds of cows are kept for dairying purposes. Besides the common mongrel cattle generally seen, some Jerseys are maintained by a few farmers who sell butter to the local markets. But the butter thus produced could not compete in the markets of the large cities, because it is deficient in quality and flavor as compared with the northern product. This is probably due in a great measure to the character of the feed. The hogs are the small, slender rangers of no, or at best a slight, admixture of blood of established breeds. They live chiefly by foraging, except in the fall, when they are fed on peanuts. A few sheep are pastured in the pine woods, and common goats are kept to furnish fresh meat for the home table. According to the census of 1900 the average value of live stock per farm in Decatur County was $173.

Very little machinery is used. The plows are small and require only one horse. The seeding is mostly done by hand, and the sweep style of cultivator is generally used. A very few disk plows have been introduced, and on the largest tobacco plantations disk harrows and other modern implements may be found. The horsepower sugar-cane press is a common piece of equipment on the average farm. The average value of farm machinery per farm is $42.

According to the last census returns 51.3 per cent of the farms in the county are operated by the owners, and probably nearly all of those classed as owners are white. The tenants are chiefly negroes. Both the cash and crop-rent systems are practiced.

The size of farms varies from less than 100 acres to several thousand, and farms of several hundred acres are numerous. The area of cultivated land on each farm is relatively small, and ranges from about 30 to 250 acres. A large part of the area is occupied by forests. The census returns give the average size of farms as 134.4 acres, of which about one-third is improved. A large tobacco corporation owns a tract of many thousand acres in the south central part of the area, on which the chief products are tobacco and sugar cane. The cultivated land of this immense tract is divided into about 25 farms, and each is superintended by a foreman, under the direction of the plantation manager.

Most of the farm work is performed by colored labor, except on the small farms, where the white owner and his family do most of the work. Where a large number of hands are employed they are usually under the direction of a white overseer. The wages range from 30 cents a day for women and children to 75 cents for men, and this does not include board.

Cotton has long been a staple crop and is produced widely throughout the area, but to a less extent at present than formerly. It grows best on the heavy red clay and the low rich sandy soils along the streams. The Sea Island cotton, of which only small quantities are produced, yields only about half as much lint as the short-staple variety, and is more expensive to cultivate. The wilt disease and black rot affect the crop in a small way. The former is said to be most injurious on very heavy soils. Injury by insects is not serious.

Corn has a large acreage, but the yield is rather small, the average for the county being about 8 bushels per acre. The white dent strain is generally grown. It is all used for local consumption.

Sugar cane has increased in prominence as a money crop within the last few years, and is very generally grown. A large number of barrels of sirup are shipped from the area annually, and Cairo, a town just east of the area, is the largest shipping point for this product in the Southeast. At Amsterdam, on a branch railroad from Climax, is located a mill equipped for manufacturing sugar. Part of the product of this mill also is sold as sirup. Sugar cane does best on the Norfolk fine sandy loam, and well on the Portsmouth sand if the soil is sufficiently drained. It is produced on other types, and on the Orangeburg fine sandy loam the yield is large, though the sirup is inferior in quality and color.

Oats are grown in a limited way for pasture and feed. Peanuts, cowpeas, and velvet beans are grown for feed, but the acreage of the last two is quite small.

Truck crops, melons, and small fruits are only produced for the small local markets. Around Calvary collards are grown in considerable quantity for seed, which is shipped to northern seedsmen. Two miles northwest of Bainbridge a vineyard covering 100 acres is being established this season, and melons and truck are being grown for the northern markets. The grapevines are planted on soil composed of from 7 to 20 inches of dark-gray sandy loam, underlain by a heavy reddish-yellow clay of a rather impervious character. The surface is undulating and has good natural drainage, except in limited areas.

Tobacco is the most prominent crop in the area, both the Havana filler and the Sumatra wrapper being grown. The former type is the less important, and is grown in the open field. The present low price of the product limits the extent of its cultivation. The Sumatra is grown under expensive shades of lath and boards, and is heavily fertilized. The construction of the shade costs from $200 to $300 an acre, and the annual outlay for fertilizers ranges from $50 to $75 an acre. One company has about 550 acres of tobacco shade, and the numerous small growers will increase the total amount to probably 800 acres. In 1900 the acreage of both types of tobacco in Decatur County was 1,261 acres, and the yield 681,160 pounds. Practically all of this acreage was in the area surveyed. The final price (price to the manufacturers) of the wrappers ranges from $1 to $4 a pound. The acreage in this crop was considerably increased during the last year. Thus far its cultivation in the county has been confined to the southern part of the area surveyed. The filler leaf is most successfully grown on the Orangeburg fine sandy loam, and the wrapper does best on the Norfolk fine sandy loam and the Gadsden sand. The Norfolk sandy loam and the Norfolk sand produce a fine leaf, but in smaller quantities, and the crop on these types is more affected by summer droughts, since irrigation is not practiced in this county as it is in Gadsden County, Fla. The most satisfactory soil for the Sumatra leaf is a lemon-yellow sandy clay, containing few iron pebbles and overlain by about 18 inches of dark-gray sandy loam. Other types of soil in Gadsden County produce Sumatra tobacco, but in a less degree of perfection. On those soils having a red clay subsoil the burn and color of the wrapper leaf are sometimes inferior. The tobacco industry gives employment to hundreds of men, women, and children.

The same types of soil on which tobacco is grown successfully in the southern part of the area occur also in the northern and central parts, but the belief is prevalent among the tobacco buyers that a good leaf can not be grown in these latter positions. The impossibility of growing a fine tobacco in the open pine forests in the central and northern parts of the area remains yet to be demonstrated by a careful trial under favorable conditions. Records have been obtained of good crops in such positions.

The naval stores industry is an important one, and a number of turpentine stills are operated in the area. The longleaf pine in nearly every part of the region has been tapped by the boxing system. In one instance the new cup method is in operation. Turpentine orcharding and lumbering are rapidly depleting the forests, which were once very extensive. The longleaf pine thrives naturally on the soils of this region, and a cleared field, if left untilled, is soon covered with a thick growth of young pine.

Two main lines of railroad pass through the area, intersecting at Bainbridge. The Atlantic Coast Line runs east and west from Montgomery, Ala., to Savannah, Ga. Branch lines connect Climax with the Louisville and Nashville Railroad at Chattahoochee, Fla., and with Amsterdam, in the center of the tobacco and cane growing district. The Georgia, Florida, and Alabama Railroad extends from Tallahassee, Fla., to Cuthbert, Ga., and is a direct line to northern cities. The Flint River is navigable for small steamers as far up as Bainbridge.

The country roads are constructed from the natural soil; hence many long stretches of road are very sandy. Only a few steep slopes occur, and these are chiefly in the southern part of the area. The sandy character of the roads materially reduces the rate of travel and the loads that may be drawn.

The crops marketed outside of the area are tobacco, cotton, and sugar cane sirup. Tobacco is handled chiefly by a few large local corporations. The crop of the small farmer is sold to the large packers and by them fermented, packed, and placed on the market.

The cane sirup is shipped to the large southern cities, very little being marketed in northern cities. Cotton, being a staple product, always has a definite market, and the direct lines of railroad traversing the area place it in easy connection with distributive exchanges on the coast. The local market is limited and easily supplied. All the crops not mentioned above are consumed at home. The lack of a sufficient home market and the distance to large markets have limited the production of melons, small fruits, and truck crops, to which large bodies of soil in the area are naturally adapted.

SOIL SURVEY OF THE GAINESVILLE AREA, FLORIDA.

By **THOMAS D. RICE** and **W. J. GEIB.**

LOCATION AND BOUNDARIES OF THE AREA.

The Gainesville area is located in the peninsula portion of Florida, about midway between the extremities of the State. The area is rectangular in shape and covers two maps of the United States Geological Survey, known as the Arredondo and Williston sheets, which were used as a base for the preparation of the soil map which accompanies this report. The limits of the area are the parallels 29° 15′ and 29° 45′ north latitude and the meridians 82° 15′ and 82° 30′ west longitude, including in both land and water surface about 534 square miles, or of land alone 310,208 acres, or about 485 square miles. Parts of Levy, Marion, and Alachua counties lie within the area.

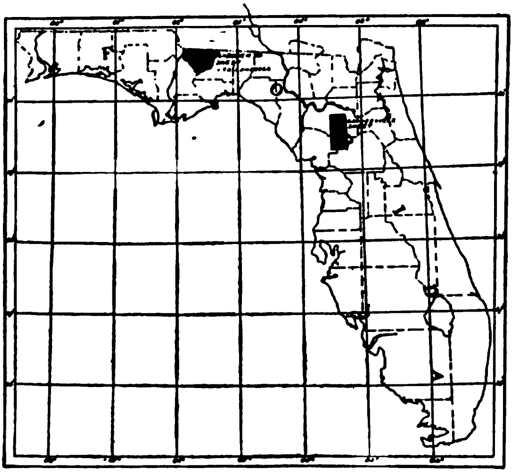

FIG. 10.—Sketch map showing location of the Gainesville area, Florida.

Gainesville, with a population of about 5,000, is the largest town. Micanopy is the center of a prosperous trucking and orange-growing community. The smaller lumbering towns of Williston, Montbrook, and Morriston lie within the limits of the survey.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

It was not until after the transfer of Florida to the United States that pioneers began to come into this area from the adjoining States. In 1825 the first house was built on the present site of Gainesville.

A few years later there were two white families located near the village of the friendly Indian chief Micanopy, from whom the town later took its name. The Indian wars broke out with great violence in 1835. The center of the trouble was about this village, and the white settlers, with few exceptions, were forced to leave the area. When the Indians were finally subdued and removed to their western reservations, the real agricultural history of the area may be said to have begun. A number of South Carolinians came to grow the long staple Sea Island cotton, which was a very profitable crop. Sugar cane was extensively grown by these planters for making both sirup and sugar, and tobacco, rice, sweet potatoes, and corn were also produced. In 1859 Judge Day, of Micanopy, started the first orange grove of this area by budding the sweet orange upon the wild sour stock, which had hitherto been considered worthless. The fruit at this early date met with a ready sale and the profits of the orange-growing industry caused its rapid expansion.

The prosperity of the State was interrupted in 1860 by the approaching outbreak of the civil war. In the end, however, the war resulted beneficially to the State from a material standpoint. Many of the soldiers, pleased by the climate or attracted by the resources of the region, returned to make it their home. Capital was brought in, railroads were rapidly extended, and a broad prosperity resulted.

The first industry to assume importance was the growing of Sea Island cotton, and for several years after the war large profits were made from this crop. Later the caterpillar proved a great pest, and in some localities the cultivation of cotton was abandoned. Attention was then turned to the orange groves, which were wonderfully productive and profitable, and as transportation facilities to the northern markets improved the growing of other fruits and vegetables was attempted. Before 1880 the trucking industry had begun to assume importance, and as early as 1883 nearly 100,000 crates of vegetables were shipped from the vicinity of Arredonda alone. After this time more attention was paid to oranges, and the greater number of the immigrants to the State came with the intention of starting groves. The soil and apparently the climate of this area were especially adapted to the production of citrus fruits, and the oranges of central Florida held a place in the market second only to the famous Indian River fruit.

The wildest speculation in Florida lands now ensued. The light, sandy land, which had been considered of but little value, sold for from $20 to $50 an acre, and the hammock lands for much more. About the year 1890 phosphate was discovered within the limits of this area, and the most exaggerated views were held of the extent and value of the deposits. The abnormal conditions and the inflated land values brought about by these causes could not long endure, the boom collapsed, and agriculture became greatly depressed.

The return to normal conditions through natural causes was hastened by the great freeze of 1895. To those who had made orange growing their sole work the blow was disheartening. Many of the growers had spent the best years of their lives and their whole fortunes in bringing their groves into bearing. A large number of this class left the State; others went to the southern part of the State, where groves could be grown more safely. Those who remained branched out into other lines of agriculture and began to give more attention to general farming. Although competition with southern Florida has been a disadvantage with which the truck growers of this area have had to contend, vegetables have been grown extensively about Gainesville and Micanopy, and in most cases good profits have been realized. On the whole, it may be said that the farmers have been so successful that there now remains little visible effect of the freeze on the general prosperity of the farming population.

CLIMATE.

The following tables, taken from the records of the Weather Bureau stations at Gainesville, within the area; at Archer, on its western border, and Lake City, in an adjoining county on the north, show the normal monthly and annual temperature and precipitation, and the occurrence of the last frost in spring and the earliest in fall.

Normal monthly and annual temperature and precipitation.

Month.	Gainesville.		Archer.		Lake City.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	° F.	*Inches.*	*° F.*	*Inches.*	*° F.*	*Inches.*
January	54.4	3.07	55.3	3.01	56.1	3.70
February	56.6	3.57	58.6	3.77	56.1	4.64
March	62.6	3.98	62.9	3.89	64.1	5.04
April	67.7	2.45	68.0	2.89	68.8	3.11
May	75.6	2.96	75.0	3.78	76.2	2.84
June	82.1	6.83	79.0	8.10	80.6	6.44
July	81.5	6.84	80.5	5.84	81.1	7.28
August	81.0	8.76	81.7	7.17	81.4	6.25
September	77.4	4.73	79.2	6.20	77.9	5.84
October	70.1	2.79	71.6	2.96	70.6	3.08
November	61.8	2.00	65.7	2.41	61.7	3.28
December	56.6	3.36	57.8	3.05	56.7	3.98
Year	68.9	51.36	69.6	53.07	69.3	55.48

Dates of first and last frosts.

Year.	Gainesville.		Archer.		Lake City.	
	Last in spring.	First in fall.	Last in spring.	First in fall.	Last in spring.	First in fall.
1897	....	....	Feb. 28	Dec. 29	Feb. 28	Dec. 28
1898	Feb. 2	Dec. 6	Feb. 23	Dec. 6	Feb. 23	Dec. 6
1899	Feb. 15	Dec. 30	Mar. 8	Dec. 5	Mar. 8	Dec. 3
1900	Feb. 19	None.	Feb. 26	Nov. 10	Feb. 26	Nov. 18
1901	Mar. 17	Nov. 17	Mar. 18	Nov. 16	Mar. 7	Nov. 16
1902	Feb. 19	Dec. 27	Mar. 19	Nov. 28	Feb. 25	Nov. 28
Average	Feb. 20	Dec. 13	Mar. 6	Dec. 1	Mar. 1	Dec. 1

It will be seen that on an average nearly nine months of the year are free from frost. The truck growing, however, is done almost entirely in the winter months, these being so mild that, though light frosts are of frequent occurrence, vegetables—such as lettuce, cabbage, pease, and beans—and strawberries mature in the open air. A light covering for vegetables on a frosty night is of great benefit, and insures a profit which might otherwise be lost by the checking of the growth of the crop. The rainfall is usually well distributed throughout the year, but the heaviest precipitation occurs in summer, when, during the rainy season, showers are of almost daily occurrence. Droughts may occur in the winter when rain is most needed by the truck; therefore the careful truck grower finds it good policy to have an irrigating plant to operate in case of need. These plants are of the simplest construction, and are inexpensive, as the plots to be watered are small. With these simple safeguards against climatic extremes, the truck grower can calculate the results of his labor as closely in Florida as in other agricultural communities where crops are grown in season.

The peninsula of Florida owes its prosperity in large measure to its mild and agreeable climate. The soils are not of a character to encourage a system of general farming in competition with more favored localities, but a mild, semitropical climate has combined with the sandy soils to build up a great trucking industry. In addition, the material prosperity of the State has been enhanced by the thousands of visitors that flock thither each winter to regain their health or to escape the severity of the northern winters.

Since the destruction of the orange groves in this part of the State by the severe freeze of 1895, only the groves in the lake region about Micanopy have been brought back into bearing. In this connection it is interesting to note the severe freezes that have occurred in Florida within historic times.

The first very cold weather of which we have any authentic account was in 1766, when all the tropical fruits in the country except the orange trees were destroyed. Very cold days occurred in 1774, 1799, and 1828, but only in 1835 was there a freeze to compare in destructiveness with that of 1895. The freeze of 1835 lasted ten days, and was very severe for about three days. The mercury in some parts of the State reached 7° F. The orange groves, both wild and cultivated, were killed as far south as the twenty-eighth parallel of latitude, and many of the trees never started again, even from the roots. In 1885 a cold wave killed the young trees and did considerable damage to the bearing groves.

The temperature did not fall as low in the freeze of 1895 as in some which preceded it, but the destruction of the groves was the result of two cold waves coming in succession, and of the impaired condition of the trees at the time of the latter. The first cold wave occurred on the night of December 29, 1894, when the mercury in this area descended to about 18° F. Some damage was done to the groves, but the trees were then dormant, and a new growth was soon put forth. While in this condition, on the night of February 7, 1895, the trees were subjected to a second cold wave, in which the mercury stood at 16° F., and all citrus fruit trees were killed to the ground. Sprouts started from nearly all the stumps, and there was a general disposition on the part of the growers to restore their groves from these shoots, but the cold winters which followed killed back this young growth and effectually discouraged the industry in the greater part of the area. The growers about Micanopy who persevered in their attempts now have their groves in bearing.

While oranges will always be grown, and large profits may yet be realized by those who have restored their groves, the development of the industry on a large scale in this area will always be hampered by the possibility of a freeze, although only two killing freezes have been recorded since 1766. It is generally considered advisable, however, for those who can do so without too great expense to restore their groves, as the profits are well worth the risk.

PHYSIOGRAPHY AND GEOLOGY.

A number of interesting physiographic features are represented in the Gainesville area. Properly to understand the topography of the region, which the soils follow to some extent, it is necessary to know something of the geological history.

The land surface of the peninsula of Florida, as it stands to-day, owes its position to successive upheavals and depressions and to the accumulations of beds of limestone, sand, and clay during the period of submergence below the sea. The primary uplift was in Eocene times, and the deposits that make up the backbone of the central part of the State are of Vicksburg age. These are limestones, containing the disklike fossil remains of the *Orbitoides mantelli*, which may be found a short distance below the surface in any part of the area. Later formations were deposited over this Vicksburg limestone, and during the last submergence to which the region was subjected a heavy stratum of sand was laid down over the entire peninsula. The breaking up of the land surface into its present condition has been brought about by the removal of this mantle of sand by stream action and by the dissolution of the limestone bed by the chemical and mechanical action of subterranean waters. These agencies have resulted in an eroded region, ranging in height from 50 to 200 feet above sea level, in which are sharply cut valleys and a few areas of plateaulike appearance, where the original sand cap has not undergone much change. In the eroded areas the soils vary as the limestone is approached, and in some places in proportion as the limestone itself has weathered. Along a line extending across the area from north of Bennington toward Ocala is an outcrop of shell flint, a corniferous limestone of such hardness that it has resisted the agencies of weathering. In some localities near this outcrop the unweathered rock directly underlies the sandy top soil; in most places, however, there is a calcareous clay stratum overlying the rock. The prevailing type of limestone is rapidly yielding to the solvent power of the underground waters, as is evident from the many sink holes throughout the area, where the earth has caved in to fill a subterranean cavity. Considerable streams disappear into some of these sinks, and a number of caverns formed by the streams are found in this region. Lakes and ponds, also formed by the lowering of the land surface through these agencies, are scattered over a large part of the area. South of Gainesville, in what is known as the Lake Region, the bodies of water are larger and more abundant. Some of these lakes are considerably lower than the surrounding country, and their slopes are steep and well eroded. In this region the weathering of the exposed limestone has produced the so-called " heavy hammock " soils.

The partly eroded areas from Fairbanks westward and southward to the Lake Region have a sand covering of from 3 to 20 or more feet in depth, and here is developed the typical Norfolk sand.

The largest of the comparatively uneroded areas is found north of Gainesville. There are smaller detached areas around Micanopy and Wacahoota. The country is almost level and ranges in height from 160 to 200 feet above sea level. A few small streams carry the surface water from these tracts, but no general stream systems have been established and the drainage is very poor.

The numerous areas designated on the map as lakes or prairies are very shallow depressions, partly filled with water, which varies in depth in dry and wet seasons. The water, 3 feet or less in depth, is filled with a mass of coarse water grasses, water lilies, and other aquatic plants. This vegetation furnishes pasture for large herds of cattle when the pasture on the uplands has given out.

The largest of these is Alachua Lake or Payne Prairie, a few miles south of Gainesville. When first known to the early settlers this area was a dry prairie, used as a grazing ground for the cattle of the Indians. Later a sink near its eastern border, which received the waters of a small creek, became clogged and the prairie was overflowed, creating a lake 8 miles long and 4 miles wide.

These water-covered prairies have no agricultural value except as pasture. The bottoms are made up of white sand washed in from the higher lying lands. There is little present possibility of draining these areas profitably.

SOILS.

The soils of the Gainesville area have been classified into six types. There is not a wide range in texture between the surface soils of the several types, and the classification depends on the depth and character of the subsoil and the crop-producing power of the soil. The latter property is strikingly exhibited in the variety of the forest trees which the soils support. The reason for the difference in timber growth has not been determined. It is not clear why the Norfolk sandy loam should not produce the heavy hardwood growth of the Portsmouth sandy loam areas instead of longleaf pine alone; or why certain sandy hammocks should support this heavy growth while the Norfolk sand grows only pine and scrub oak. It is known, however, that soils which support the hammock growth are underlain by clay at a depth of less than 5 feet, but such clay subsoils do not always produce the hardwood timber growth.

The names of the soil types of the Gainesville area, with their respective areas, are given below.

Areas of different soils.

Soil.	Acres:	Per cent.	Soil.	Acres.	Per cent.
Norfolk sand	139,328	44.9	Gainesville sand	7,744	2.5
Norfolk sandy loam	86,784	28.0	Muck	128	.1
Portsmouth sandy loam	40,384	13.0	Total	310,208	
Portsmouth fine sand	35,840	11.5			

NORFOLK SAND.

The top soil of the Norfolk sand is usually a gray or brown sand of very fine to medium texture, containing a small percentage of organic matter, to which it owes its darker color. It ranges in depth from 5 to 8 inches. The subsoil is a yellow or white sand of similar texture, extending to a depth of more than 3 feet. The Norfolk sand is loose and incoherent, the subsoil being more so than the soil, as it lacks the binding effect of the organic matter found nearer the surface.

The Norfolk sand is the most extensive soil type found in the Gainesville area. The largest area of the type is a strip having a northeast and southwest direction, and including the towns of Fairbanks, Gainesville, and Archer. It is followed in a general way by the Seaboard Air Line Railroad. Another area occupies the southwestern corner of the survey, includes the town of Morriston, and stretches along the southern border of the area as far as Blitchton. Besides these extensive developments, there are numerous irregular patches of the Norfolk sand included by other types. In these spots the soil sometimes has a clay subsoil below 3 feet, but the depth of the sand and its crop-producing value justify its classification with the Norfolk sand. There are other parts of this soil where the sand is finer than in the typical profile, but these areas were not sufficiently important to warrant the establishing of another type.

The elevation of the Norfolk sand areas varies in different parts of the area from 50 to 200 feet above sea level. The country is everywhere rolling and in some parts almost hilly. The inequalities of the surface are increased by the sink holes, where the earth has subsided into some cavity hollowed into the underlying limestone. These sinks receive the local drainage, and in some cases have become the centers of extensive drainage systems.

The drainage of the Norfolk sand is good, and the water supply for the use of growing crops is well regulated. The power of this soil to retain a uniform water supply is remarkable. The soil is always moist immediately beneath the surface, even after prolonged droughts, and crops seldom suffer for lack of water. Another valuable feature is that the soil moisture is readily delivered to the growing crop, so that plants which would perish with the same moisture content in almost any other soil may flourish on this soil. The Norfolk sand maintains about 4 per cent of water,[a] and this seems to be ample to meet the needs of the truck crops, while 6 per cent makes the soil quite wet. Just what property of this soil enables it to maintain so uniform a moisture content has not yet been ascertained.

The Norfolk sand is the type of soil so generally utilized along the Atlantic seaboard for growing such crops as have to be forced to an early maturity to meet the demands of a winter market. The excellent drainage and warmth of this soil, together with its ready response to the stimulating effect of commercial fertilizers, make it admirably adapted to this system of intensive farming. The soil, however, while very productive under favorable conditions, requires heavy applications of commercial fertilizers to secure the best results with the forced crops. For this reason the Norfolk sand has of late years been neglected in favor of the more productive hammock soils, with their larger content of organic matter. This is especially the case in the production of cabbage and lettuce, which thrive on those lands. Watermelons and cantaloupes grow to perfection on the Norfolk sand. Strawberries, beans, pease, and potatoes are still grown to some extent. The citrus fruits also do well, but since the freeze of 1895 and the succeeding cold winters the groves have with few exceptions been entirely neglected.

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[a] Bulletin No. 13 of the Division of Soils.

By far the greater part of the Norfolk sand is covered by forests of longleaf pine, with a characteristic growth of scrub oak on many of the knolls and ridges. The coarse grasses which grow on these pine lands furnish a fair pasturage for cattle during the spring and early summer. The more progressive cattle raisers are trying to provide winter pasture by growing forage crops. The best plant for this purpose so far found is the velvet bean. Wherever the land has been cultivated a thick growth of crab grass covers the ground. This is sometimes cut for hay, and the practice should become more general.

Cotton and corn are generally grown on the Norfolk sand. The yields are light, but the expense of cultivating these crops is not great.

The following analyses of typical samples of the Norfolk sand show the texture of the soil and subsoil:

Mechanical analyses of Norfolk sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10607	1 mile S. of Micanopy.	Coarse to medium sand, 0 to 8 inches.	1.0	11.7	28.9	44.0	9.0	2.7	2.4
10609	1¼ miles SE. of Gainesville.	Coarse to medium sand, 0 to 6 inches.	.7	11.8	28.8	44.6	9.0	1.9	2.8
10610	Subsoil of 10609	Coarse to medium sand, 6 to 36 inches.	.5	10.1	25.7	47.7	10.8	1.7	2.7
10608	Subsoil of 10607	Medium to coarse sand, 8 to 36 inches.	.9	11.5	28.6	43.8	9.7	2.4	3.9

NORFOLK SANDY LOAM.

The Norfolk sandy loam is a medium to coarse sand having an average depth of 18 inches. In texture it does not differ from the Norfolk sand, except that in some localities, where the top soil is not deep, there is a slight loaminess of texture. There is also usually present more organic matter than in the soil of the Norfolk sand, which adds to the loamy character of the surface soil. The subsoil is a sandy clay which passes quickly into a heavy, stiff drab clay, mottled with iron and containing iron crusts. There may also be present fragments of partially weathered limestone. Nearly everywhere the hard unweathered limestone is found at a depth of from 3 to 4 feet, but rarely without the overlying stratum of clay derived from it.

The Norfolk sandy loam occupies a large, irregular area, stretching from a few miles north of Archer, where it enters the Gainesville area, southeastward toward Ocala. It merges into the hammock lands on the east and into the Norfolk sand area about Morriston on the south. There are also small detached areas south of Micanopy.

The topography occupied by the Norfolk sandy loam is that of a gently rolling upland. There are no abrupt changes of elevation, although the type may occur at almost any height above sea level.

The drainage of the soil is very good, as the slope of the land is sufficient to remove the excess of water that might otherwise be retarded by the clay subsoil. The moisture is well retained, and crops seldom suffer even in periods of protracted drought.

On the Norfolk sandy loam may be seen the best system of farming practiced in the Gainesville area. Here the farmers are producing their home supplies and making the more speculative money crop a matter of secondary importance. This system is best adhered to in the vicinity of Williston, and the good results are evidenced by the appearance of the farms and the contentment of the farming class. Before 1895 the orange groves took the time and attention of the farmer, and in many cases were his sole dependence for an income. Since the destruction of the groves more attention has been given to the general farm crops, and corn, potatoes, fruits, and vegetables for home needs have been grown. The greatest advancement, however, has been made in the production of pork for home or local consumption. Peanuts are grown to fatten the hogs, and farmers who are in a position to know assert that meat can be produced in this way more cheaply than in the West, where 25 bushels of corn are grown per acre. The principal money crop in the vicinity of Williston is cucumbers. For several years the farmers have made a specialty of this crop, to which the Norfolk sandy loam seems especially well adapted, and large average returns have been secured. It must be kept in mind that this profit is almost clear, as it is made after the home needs have been supplied from the farm. As a result of this system of agriculture, there are few farmers that are not in better circumstances than before the loss of the groves.

The greater part of the Norfolk sandy loam is uncleared. The timber growth consists entirely of longleaf pine, usually thickly set and with no undergrowth. In the spring and early summer fair pasturage is found for the cattle in the native grasses of these uplands. In the winter this pasture is almost worthless, and if the grass be killed by early frost the cattle are reduced to the point of starvation. A very small quantity of feed would suffice to carry the cattle through the winter, and it is surprising that more attention is not given to the subject of forage crops.

Mechanical analyses of the Norfolk sandy loam are given in the following table:

Mechanical analyses of Norfolk sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
10619	1 mile NW. of Flemington.	Gray sand, 0 to 18 inches.....	0.4	8.0	24.4	43.8	15.9	3.2	3.9
10623	½ mile S. of Elmwood.	Loose sand, 0 to 10 inches....	.2	3.0	10.7	57.2	21.5	3.4	3.9
10624	Subsoil of 10623..	Brown sandy clay, 10 to 36 inches.	.1	2.6	7.8	41.5	15.2	11.9	20.1
10620	Subsoil of 10619..	Gray, stiff sandy clay, 18 to 36 inches.	1.0	5.6	12.5	22.8	8.0	20.6	29.5

PORTSMOUTH FINE SAND.

The Portsmouth fine sand has been mapped as a distinct soil type on account of its physiographic and drainage features and their effect on the crop-producing power and consequent commercial value of the land rather than from any marked difference in texture between it and the Norfolk sand. The type is locally known as the "flat woods" or "scrub land." The soil is a fine to medium sand, and is usually dark-gray or black from the presence of organic matter. Where this organic matter is not present the sand is bleached and white on the surface. The depth of the top soil is usually about 16 inches. The subsoil, wherever the usual undrained conditions prevail, is a chocolate-brown sand, similar in texture to the soil. The distinctive color is given the subsoil by finely divided ferruginous material. It acts as a cementing agent and gives to the soil a loamy texture, and in some places forms a soft iron crust. This material decreases in compactness with depth, and below 3 feet the sand is pure white, and, when wet, quickly flows in and fills any hole sunk below this depth. For this reason it is locally known as "quicksand."

The largest area of the Portsmouth fine sand is found north of Gainesville, extending from that place to the northern limit of the survey. There are also smaller areas near Micanopy and Wacahoota, in which the characteristics of the type are well developed.

The Portsmouth fine sand is sedimentary in origin, and occupies the comparatively level and little-eroded stretches of plateaulike appearance which represent the original land surface of the region when it was last elevated above sea level. The most extensive area of this type occupies the most elevated portion of the area surveyed, ranging from 160 to 200 feet above sea level. The smaller areas do not attain this elevation, but in no case is the type found below the level of the country immediately surrounding.

Notwithstanding the elevation of the Portsmouth fine sand, it is the most poorly drained soil of the area. The soil itself seems to be impervious in a high degree, and the streams have not eroded tributary channels sufficient to carry off the excess of water, which stands at an average depth of 2 feet below the surface at all times, and which, after heavy rains, stands on the surface for days at a time.

The vegetation on these pine flats is characteristic. There is an irregular forest growth of longleaf pine, with a low undergrowth of saw palmetto, gallberry bushes, and, in some places, scrub oak.

With the prevailing cheapness of land there is no probability that any considerable extent of the Portsmouth fine sand will be drained and brought under cultivation. No effort is now made to cultivate it on any scale worthy of notice. Near Micanopy, where edges of the areas of this type have been drained and included in truck fields, yields are obtained similar to those from the Norfolk sand.

The following table shows mechanical analyses of samples of the Portsmouth fine sand:

Mechanical analyses of Portsmouth fine sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10627	1 mile E. of Rutledge.	Black loamy fine sand, 0 to 8 inches.	0.2	2.6	8.7	64.8	10.5	5.9	7.5
10625	½ mile W. of Rutledge.	Black loamy fine sand, 0 to 6 inches.	.5	3.1	9.5	63.5	5.6	6.7	11.1
10628	Subsoil of 10627..	Brown loamy fine sand, 8 to 36 inches.	.2	2.5	8.7	64.7	11.4	4.9	7.5
10626	Subsoil of 10625..	Brown loamy fine sand, 6 to 36 inches.	.3	3.4	9.6	64.8	6.2	4.5	11.2

PORTSMOUTH SANDY LOAM.

The term Portsmouth sandy loam is applied to a soil having a considerable range in texture, but a fairly uniform crop value. The different phases of the type have a characteristic timber growth, and are included by the local name "hammock lands." The various grades of hammock lands are locally known as the "high hammock," the "low hammock," the "light hammock," the "heavy hammock," the "heavy clay hammock," and the "marl hammock," so called by reason of the topography, the timber growth, or the character and depth of the soil and subsoil materials. The usual surface material of the Portsmouth sandy loam is a sand of medium texture, of a mellow, loamy character, and nearly everywhere containing fragments of limestone. The soil of the virgin and recently cleared portions of the type is black with organic matter, accumulated from the decay of the dense vegetation which it has supported. The depth of this sandy top soil varies from a few inches in the heavy clay hammock to 5 feet in some portions of the very light hammocks. The average depth may be placed at 25 inches. The subsoil is a stiff, calcareous, drab clay, which passes into the limestone from which it was derived at varying depths. The small areas of a phase of this type, in which the clay comes to within a few inches of the surface, are known as "heavy clay hammock." It occurs in small patches around Rockypoint and in the dense forests south of Wacahoota, but in no case was an outcrop of this material found large enough to map as a separate type.

The largest development of the Portsmouth sandy loam occurs around Payne Prairie or Alachua Lake, and extends south and east into the Lake Region. Many smaller areas are found near the lakes and water courses—the usual position of the type throughout the area.

The Portsmouth sandy loam is everywhere marked by a natural growth of hardwood trees, consisting of a mixture of white oak, live-oak, water oak, hickory, magnolia, dogwood, and an occasional cabbage palmetto. These, with an undergrowth of saw palmetto, vines, and briars, form, in some places, an almost impenetrable jungle. The pine is rarely seen in this growth, and the cypress only in the most depressed, swampy localities.

Notwithstanding the natural facilities for drainage afforded this soil by its topography, there is much complaint by the truck growers that in wet seasons the drainage is inadequate. The heavy clay subsoil in many places seems to confine the water about the roots of the growing plants, with disastrous results. Drainage by surface ditches is resorted to, but considerable judgment is required to place the drains properly, and in many cases it can only be done by experiment.

Underdrainage by tiles would no doubt be more effective and more easily accomplished.

The water content of the hammock soils is on an average about twice that of the Norfolk sand, but there is no such uniformity in the supply throughout the year. Evaporation takes place from these soils very rapidly, and they can not maintain their water supply through long droughts. For this reason the valuable grasses which flourish during seasons of ample rainfall do not survive the droughts, and the heavier phases of this type are not so well adapted to stock raising as they would seem to be from their texture.

The Portsmouth sandy loam is, however, the strongest and most productive soil of the area, and for the purposes for which it is utilized it is probably the most valuable land in the State. The crops most generally grown, to which the soil seems best adapted, are lettuce, cabbage, pease, beans, and cantaloupes. This is the only soil on which the production of citrus fruits has been attempted since the great freeze. Near Micanopy oranges and grape fruit are grown with profit. There is no attempt to protect the trees from cold by covering or by building fires in the groves. In the case of guavas, mangoes, and lemons, the trees are covered during cold weather.

The following analyses show the texture of samples of the Portsmouth sandy loam:

Mechanical analyses of Portsmouth sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10613	1 mile NW. of Rockypoint.	Coarse to medium sand, 0 to 25 inches.	0.5	8.1	20.9	44.7	16.9	5.6	3.1
10615	2¼ miles SE. of Johnson Pond.	Black sandy loam, 0 to 8 inches.	.6	4.6	13.7	50.0	15.5	11.3	4.0
10611	¼ mile W. of Rockypoint.	Gray loamy sand, 0 to 28 inches.	.8	6.0	18.6	46.1	18.4	6.2	4.2
10616	Subsoil of 10615..	Stiff heavy clay, 8 to 36 inches.	.7	2.3	4.0	20.9	18.7	36.0	17.1
10612	Subsoil of 10611..	Gray loamy clay, 28 to 36 inches.	.6	5.4	13.4	34.4	14.5	9.1	22.6
10614	Subsoil of 10613..	Gray heavy clay, 25 to 36 inches.	.4	8.8	18.8	34.7	8.0	2.6	26.7

The following sample contained more than one-half per cent of calcium carbonate ($CaCO_3$): 10616, 1.86 per cent.

GAINESVILLE SAND.

The Gainesville sand is a gray loamy sand 8 inches deep, containing much organic matter, underlain by a brown loamy sand of looser structure. The subsoil varies in depth, but usually at less than 3 feet it is underlain by a calcareous clay or by partly weathered limestone. Both soil and subsoil, as a rule, contain limestone fragments at all depths, and these, with the weathered products, give the soil the loamy characteristics which distinguish it from the other sandy soils of the area. Its color is also distinctive, being darker than the Norfolk sand, but not so dark as the Portsmouth fine sand. It is mellow and easily tilled, and tenant labor can be profitably employed in its cultivation.

The most extensive development of the Gainesville sand occurs in the northwestern part of the survey, and the characteristics of the type may best be seen near Bennington. There are other small areas of this soil, many patches of it about Gainesville being too small to indicate on the map. In some places the term "chocolate hammock" is applied to these spots, but the term is not restricted to this type of soil.

The Gainesville sand occupies the high, rolling upland, similar in appearance to that covered by the Norfolk sand. The soil is well drained and crops rarely suffer in seasons of excessive rainfall. While moisture is fairly well retained, the Gainesville sand does not withstand drought so effectively as the Norfolk sand.

A larger proportion of the Gainesville sand is under cultivation than of any other soil in the area, but more than half of it is yet uncleared. The characteristic timber growth is a mixed forest of pine and hardwood. The pines are large and rather scattering, and the interspersed growth consists of hickory and several varieties of oak. The magnolia is rarely seen on this type of soil. This soil, on account of its timber growth, is called, locally, "second hammock."

The principal and most profitable crop at the present time is the long staple or Sea Island cotton. The soil produces a very fine grade of this cotton, but seed for planting is imported from the sea islands to prevent any deterioration of the product. The planters who came to the State to grow cotton before the civil war, or shortly after, selected this type of soil. They farmed well and their descendants follow the same practices, so that to-day we find a thrifty class of farmers on this type of soil. Besides growing cotton, they produce the general farm crops and raise cattle and hogs. Corn, oats, and peanuts are the crops most successfully grown.

The following table shows the texture of typical samples of the Gainesville sand:

Mechanical analyses of Gainesville sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10597	1 mile NW. of Paradise.	Gray medium sand, 0 to 20 inches.	0.4	10.4	23.1	49.8	12.5	2.4	1.1
10599	½ mile SW. of Micanopy.	Coarse to medium sand, 0 to 12 inches.	2.8	14.6	29.5	39.5	9.7	2.3	1.1
10595	2¼ miles E. of Wacahoota.	Medium to coarse sand, 0 to 10 inches.	.4	9.7	23.4	46.9	14.5	3.3	1.6
10596	Subsoil of 10595..	Brown sand, 10 to 36 inches.	.6	8.6	24.9	45.6	14.0	3.2	2.2
10598	Subsoil of 10597..	Brown medium sand, 20 to 36 inches.	.8	10.3	22.5	46.8	13.1	2.5	3.7
10600	Subsoil of 10599..	Coarse to medium sand, 12 to 36 inches.	2.1	14.5	28.9	38.3	9.4	1.7	4.8

MUCK.

In the so-called "hammocks" there are depressed areas that have been filled in by accumulations of vegetable mold to a depth of from 1 foot to 3 feet. These Muck areas are unimportant, of only a few acres in extent, and only one has been indicated on the soil map. This lies about 5 miles southeast of Gainesville, on the shores of Newnans Lake. It has not been brought under cultivation. Celery was once grown on a small area of Muck near Gainesville, with fair success. The soil should be well adapted to this crop.

AGRICULTURAL METHODS.

Since the destruction of the orange groves by the severe freeze of 1895 the farmers of this area have turned their attention largely to the growing of vegetables. The soils are well adapted to truck crops, respond readily to careful management, and give profitable returns. Success or failure depends upon the stability of the northern markets, to which the vegetables are shipped, and upon the methods of culture followed in the field.

Lettuce, cabbage, cucumbers, peas, beans, eggplant, melons, tomatoes, and potatoes are successfully grown. The cultural methods are similar to those in vogue in other winter vegetable growing districts. Owing to the frosts, which often do considerable damage to unprotected plants, a method for covering the growing crop during the night is now in use among the more well-to-do farmers. Lettuce, especially, is protected in this way, since it is earlier than the other crops, and therefore in more danger from frost. Large frames, from 18 to 20 feet wide, 2 feet high at the sides, 4 feet high in the center, and of any convenient length, are erected in the field. Over each frame a light canvas is spread. This completely covers, but does not touch, the plants. The lettuce plants, which are started in smaller frames, are transplanted to the larger ones from November 1 to January 1. They are set in rows, from 14 to 18 inches apart each way, and cultivated with hoe and rake. Every night, or when a frost is expected, the canvas is drawn down and is not raised until two or three hours after sunrise. The lettuce grown is head lettuce. Under favorable conditions it will be ready for the first cutting in from twelve to fourteen weeks. Only heads which have reached the proper degree of firmness are cut. These are packed in baskets which hold from 35 to 50 heads, and are then ready for shipment. After the lettuce has been removed, cucumbers are often planted in the frames. The other vegetables are not grown in the frames, for danger of frost is past at planting time. While lettuce and cucumbers will grow and thrive without this protection and often yield large returns, the conditions can be much better controlled by using the frames, and their use is considered advisable.

Small quantities of oats and corn are grown, but the yields are very low and the supply is not equal to the local demand. The hay grown is the native beggar weed and crab grass, but this supply is also deficient. Considerable cotton (Sea Island) is also grown. The methods of culture do not differ from those in vogue throughout the South. The yields are low, but the price is high enough to make the crop a profitable one. The price of this cotton does not fluctuate with the price of the short-staple cotton.

Owing to the forcing of winter crops on the sandy soils of the area commercial fertilizers are extensively used. The fertilizer companies put out special brands for the different crops; thus they have a lettuce, a cucumber, and a cotton "special." Many farmers buy the ingredients and mix them to suit the needs of their own fields. Stable manure is used when it can be obtained, but as little stock is housed and fed the supply is limited. The owners of livery stables in the towns sell what they produce for $2.50 a load.

While different crops are grown on the same soils, no systematic crop rotation is practiced. The vegetable grower often shifts from one piece of ground to another when the location is not suitable or the yield unsatisfactory. This can easily be done, since land is abundant and cheap.

On account of the irregularity and uncertainty of the rainfall during the winter and spring months irrigation is sometimes practiced by the vegetable growers. Small pumping plants are installed on the shore of a stream or lake and pipes laid, usually above ground, to the field to be irrigated. When lettuce is grown laterals are run to different parts of the field and between the frames, if this system is used. The water is applied in a spray from small branch pipes which stand erect. If other crops are grown the water is allowed to reach the plants by running between the rows. This system of irrigation has proven very successful.

AGRICULTURAL CONDITIONS.

The farming classes of the area surveyed are in a fairly prosperous condition. Many of those who own farms near Gainesville or Micanopy live in town and thus have many advantages of which their more distant neighbors are deprived. They drive to the farm each day and superintend the different farm operations. Their homes are substantially built, painted, and kept in good repair. This is the smaller and more well-to-do class. The buildings of those throughout the country districts are not as well constructed, are often unpainted, and in poor repair. This state of affairs, however, is scarcely a fair indication of the financial condition of the owners, since the climate is very mild for nearly the entire year. The expenditure of money for substantial buildings seems to be considered unnecessary.

The greater number of the farms of the area are worked by the owners. When renting is practiced it is done on shares. When the owner of the farm furnishes one-half the fertilizer, half the stock, and half the implements, the returns are equally divided. When the tenant furnishes everything he usually gets two-thirds or sometimes three-fourths of the returns. Comparatively few of the farms are incumbered, and this is considered an indication of prosperity. In the growing of vegetables more or less speculation is always involved, and on account of a season of low prices or poor management the farmer is frequently obliged to borrow money with which to begin another crop.

The tracts of land vary in size from 2 to 2,000 acres or more. The larger areas are covered with the native forest, or, having been stripped of the timber, are now left desolate and undeveloped. Where vegetables alone are grown, and the system is intensive, the farms range from 2 to 10 acres. Where general farming is practiced, and the system is extensive, the farms run from 30 to 100 acres. The average size of all the farms under cultivation is estimated at 40 acres.

The question of labor is an important one, and the farmer is often handicapped in not being able to secure competent help when most needed. Approximately half the population of the area is colored.

The average wage by the day is 75 cents. Italian labor has been successfully introduced into some of the phosphate mines, but as yet this has not been tried by the farmers.

Considerable stock is raised in the area surveyed, though little attention is paid to proper feeding, selecting, or breeding. The cattle are allowed to run on the range and care for themselves during the entire year. In a few cases they are fed during the winter, but not enough to keep them in good condition. Through the spring and summer, a season of about six months, an abundance of nutritious pasture is furnished by the native grasses of the pine woods, crab grass, beggar weed, and some bermuda grass. During this time the cattle thrive and lay on flesh rapidly. In the fall the grasses die down and the stock is scarcely able to hold its own. In the winter, when the pasture is scant and it is necessary for the stock to travel long distances to secure enough to sustain life, the struggle for existence becomes a difficult one. The stockman counts on losing 15 or 20 per cent of his herd each winter, and in severe winters a loss of 25 per cent has been reported. The greater part of these actually starve to death. If kept in good condition the stock could easily withstand the elements, but when greatly emaciated their weak constitutions suffer from the exposure and become more subject to the ravages of disease. Those which survive the long fast and succeed in withstanding the winter exposure are mere skeletons. Although they lay on flesh rapidly when the fresh pastures appear, and seem to regain their vigor, no animal can be subjected to a prolonged period of starvation and exposure without having its vitality greatly impaired. The cattle are sold when they are four or five years old, and then weigh from 600 to 800 pounds each. They are usually sold in the fall, after a full season on good pasture. The local butchers buy a few for home consumption, but most of them are shipped farther north to feeders, who fit the stock for market. The prices obtained are low, usually from 2 to 3 cents a pound.

The condition which this state of affairs presents is a serious one. The most important problem which the stockman has to consider is the question of winter pastures and forage crops. The necessity for carrying the stock through the winter without a serious loss by death and by shrinkage in weight can not well be overestimated. The Bureau of Plant Industry and the experiment stations of the South are giving the question careful study, and the results of their work will be of great value to the stockmen of this area.

None of the grasses now grown in the area furnishes sufficient pasture for the winter. The introduction of hardy grasses and forage plants will revolutionize the stock-raising industry. Winter turf oats and hairy vetch grown together form a good winter pasture. A field sown in September will furnish pasture from January to May. If the pasturing is discontinued April 1, a crop of hay may be cut in May, or seed may be harvested in June. Rape sown in October or November would furnish an excellent flesh-producing pasture during the winter. On the Norfolk sandy loam type these crops should do well. A field of alfalfa was observed near St. Augustine on soil resembling the Norfolk sand about Gainesville. It was making a vigorous growth, and furnishing pasture for a small herd of cows. Alfalfa should be sown in the fall and not pastured the first year, or until it secures a good stand.

The hogs raised receive no more attention than the cattle, but are allowed to run at large and care for themselves. They are of inferior grade and always in poor condition. Sheep and goats are also raised, though not extensively. As they are of a more roving disposition and closer grazers than cattle they withstand the winters and the scant pasture better. Their condition, however, is in need of careful attention, for what is now yielding but a small per cent on money invested could, by careful management, be made to return handsome profits.

During the past few years the turpentine industry has been extending rapidly, principally as a result of the introduction of the cup and gutter system promoted by the Bureau of Forestry during the last three years, which makes it possible to turpentine timber already boxed to the fullest extent. A considerable area of pine timber is, however, still worked under the box system, but particularly in out of the way sections and by the least progressive operators. A large percentage of those using boxes would gladly apply the cup and gutter system, but at the present time it is not possible to secure the necessary equipment.

A chemical plant, located at Gainesville, extracts turpentine and other products from the pine wood by a new process, by means of which the trunks of trees and the stumps can be utilized. The lumbermen are fast cutting away the timber, and practically no attention is paid to the young trees now coming on. In a few years the forests will be gone, and then the work of reforesting must, of necessity, be considered.

New York, Philadelphia, Baltimore, and Washington furnish a ready market for all the vegetables grown within the area. Agents of the commission houses are kept in the field during the growing season, to deal directly with the farmer. The vegetables are consigned to the commission men, who sell them on a commission of 10 per cent. In order that the vegetables may be put on the market in a fresh condition, they must be crated carefully and transported safely and quickly. A fancy price must be received if the grower is to make a profit on his crop, for the express rates are high, and the commission, plus the first cost of production, makes the total cost very high. Gainesville furnishes a market for a small amount of farm produce, and is also a distributing center for seed and farm implements. It is also the center of the Sea Island cotton industry, which product is controlled by one firm at Gainesville.

The transportation facilities of the area are equal to the demands of production. The Cedar Keys division of the Seaboard Air Line and a branch of the Atlantic Coast Line pass through the area and intersect at Gainesville. The Gainesville and Gulf Railway, a short line of but 69 miles, also passes through Gainesville, and reaches the richest trucking districts in the area. Rock-surfaced roads are built out from Gainesville and Micanopy, and between Flemington and Williston, a total distance of 35 miles. The rock used is the limestone found throughout the area. Owing to the light character of the soils, the dirt roads are sandy. The county roads are kept in repair by a county road commissioner, who keeps a gang of men continually at work repairing and grading. The private roads are numerous, and generally in good condition, owing to the fact that they are not extensively used.

SOIL SURVEY OF MACON COUNTY, ALABAMA.

By HENRY J. WILDER and HUGH H. BENNETT.

LOCATION AND BOUNDARIES OF THE AREA.

Macon County lies near the eastern boundary of Alabama, approximately 135 miles north of the Florida-Alabama line, and comprises an area of 621 square miles. Its extreme dimensions are 34 miles from east to west and 24¾ miles from north to south. Like all other counties of the State, its outline is irregular. Tuskegee, the principal town and the county seat, is located in the north-central part of the county.

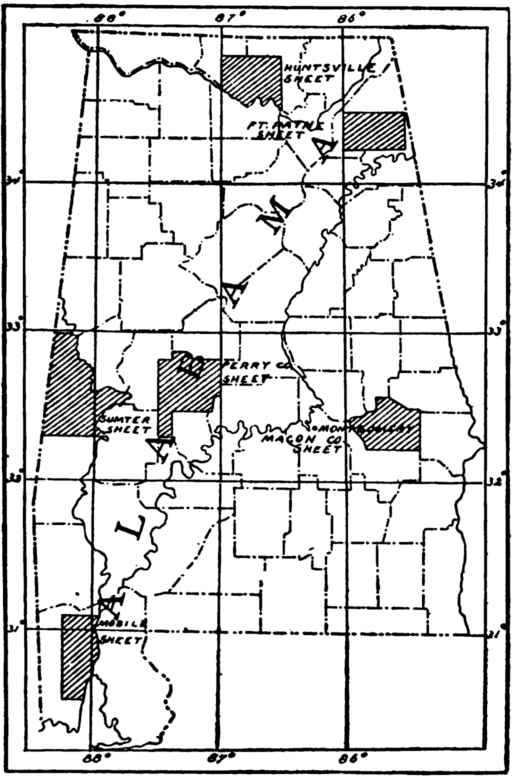

FIG. 11.—Sketch map showing location of the Macon County area, Alabama.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Macon County was established December 18, 1832, by act of the general assembly of the State of Alabama. It was named in honor of Nathaniel Macon, the North Carolina statesman. Since its organization, however, considerable portions have been set apart to Bullock and Lee counties, constituting a reduction in area of about 300 square miles.

Tuskegee was laid out in 1833. Until this time the county was but sparsely settled by the few immigrants who had come from Georgia, the Carolinas, and Virginia, and the attention given to agriculture, under the existing order of things, was necessarily meager. After the removal of the Indians in 1836, however, the population of the State increased at such a rate that it was almost doubled in the decade ending in 1841, and the development of agricultural interests in Macon County was rapid.

The principal crops were cotton, corn, sweet potatoes, oats, and wheat. Cotton was the sole money crop, and more than one-half of the tilled land was devoted to its production. Every farmer planned to grow enough corn, sweet potatoes, and oats for his own needs, and a few grew wheat sufficient for home use. Nine-tenths of the supply of meat consisted of home-grown pork. This was varied occasionally in the winter season with mutton and beef. Sorghum had not been introduced at that time, and very little sugar cane was grown. By this plan each farmer produced the chief part of the necessary supplies, and depended upon cotton for his income.

CLIMATE.

Weather records for a period longer than three years have not been kept in Macon County, and so the following data are taken from the more complete records of the Weather Bureau stations at Montgomery, Union Springs, and Wetumpka. Montgomery is 18 miles west of the Macon County line, and the records of this and the other stations are believed to be fairly representative for this area.

Normal monthly and annual temperature and precipitation.

Month.	Montgomery.		Union Springs.		Wetumpka.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	°F.	*Inches.*	*°F.*	*Inches.*	*°F.*	*Inches.*
January	48.3	5.87	45.5	4.90	46.3	4.25
February	52.7	5.34	49.2	6.85	46.5	5.56
March	57.0	6.47	56.2	6.16	58.8	5.70
April	65.4	4.30	65.6	3.68	63.0	4.38
May	72.8	4.05	73.7	3.02	73.7	2.82
June	79.4	4.67	80.7	4.38	81.7	3.23
July	81.5	4.53	81.1	5.36	82.2	5.12
August	79.8	4.13	80.4	5.00	81.7	5.84
September	75.6	2.95	75.5	2.78	....	1.88
October	65.2	2.36	65.1	3.27	65.0	3.17
November	55.2	3.38	55.0	3.47	54.9	3.36
December	49.6	4.67	47.8	4.00	47.4	4.15
Year	65.2	52.72	64.7	52.84	....	48.97

Situated in the Gulf Coastal Plain, a region of moderate winters and hot summers, the country enjoys a climate favorable to agriculture. Crops suffer occasionally from extended periods of drought, but the uniformity in distribution of the rainfall and an average growing season of two hundred and fifty-one days, entirely free from frosts, make possible considerable diversity in crop production. Periods of cold weather are short—usually from two to three days following rains, with warmer weather on the fourth or fifth day, which continues until the next rain. The summers often are quite oppressive, but moderating Gulf winds afford relief, and sunstrokes are almost unknown.

The prevailing winds are from the northeast and northwest during the autumn and winter and from the southeast during the spring and summer.

The occurrence of the last killing frosts in spring and the first in fall, for a series of years, and also the average date when such frosts may be expected are shown in the appended table.

Dates of first and last killing frosts.

Year.	Montgomery.		Year.	Montgomery.	
	Last in spring.	First in fall.		Last in spring.	First in fall.
1894	Mar. 30	Nov. 7	1900	Mar. 17	Nov. 9
1895	Mar. 17	Nov. 12	1901	Mar. 7	Nov. 16
1896	Mar. 21	Nov. 9	1902	Mar. 19	Nov. 28
1897	Feb. 28	Nov. 18	1903	Feb. 19	Dec. 18
1898	Feb. 23	Oct. 23	Average[a]	Mar. 9	Nov. 16
1899	Mar. 29	Nov. 6			

[a] Average dates for thirty-two years are Mar. 11 and Nov. 8, respectively.

PHYSIOGRAPHY AND GEOLOGY.[a]

The surface features of Macon County have the general character of a plain which slopes almost imperceptibly toward the sea. Further investigation, however, discloses three distinct physical features within the area. Along the main stream courses—the Tallapoosa River, Uphapee, Caleebee, Gubahatchee, Old Town, and Line creeks, and many of their branches—are low-lying, flat bottoms. The low terraces of such areas are subject to more or less overflow from streams which, with many horseshoe bends and other irregularities, wind through these bottoms. The upper terraces are rarely overflowed, and almost never during the crop season.

The second division includes the broad upland which lies above the highest terrace, and covers the chief part of the county. The general configuration of this upland area varies from a gently rolling to a steeply rolling plateau; and in the latter case its surface is marked by many long ridges and hills which serve as watersheds, and determine the general direction of the streams of the county. Most of these elevations are less than 500 feet above sea level.

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[a] Direct references to geological formations in this chapter are based upon the report of Eugene Allen Smith, Ph. D., State geologist of Alabama.

The third variation in surface features occurs in the southwestern part of the county, where the unevenly distributed surface materials have been removed. This has left exposed the broad, level, calcareous prairie, the topography of which is seldom broken by small ridges and conical-shaped hills, capped with the pebbles and sand beds of the drift, where these have not been completely removed. The general surface of this physiographic division is so level that the streams are very sluggish, and sloughs are of common occurrence.

Macon County lies almost entirely within the Coastal Plain, the boundary of that physiographic province passing just south of the extreme northern limit of the county. The oldest geological formations which have had any effect upon the soils of the area are the Tuscaloosa and Eutaw beds, and their influence appears only over small areas where the overlying Lafayette has suffered from erosion. The former of these deposits, which consists of mottled clays and cross-bedded sand, is first exposed about 6 miles south of the north line of the county. To the southward of this belt of Tuscaloosa materials follows a strip of some 6 miles in average width, underlain by the Eutaw sands. These are usually grayish, cross-bedded sands, which weather to red or yellow colors. The uppermost layers of this formation are characterized everywhere by shell beds, which mark the transition from the shallow water and offshore deposits of the Eutaw and Tombigbee sands to the great limestone and chalk formation of the Cretaceous period.

South of the belt of Eutaw strata beds of rotten limestone are found in the southwestern part of the county, which give rise to the "prairie soil." Along the border of the prairie, with the Eutaw sands, there is often a band of transition soil, formed by the intermingling of stiff lime soils with the red or yellow clay of a later formation. This soil has been mapped as Lufkin clay. On such lands the prevailing timber growth is post oak, and for this reason they are called "post-oak prairies." In the eastern part of the county the Eutaw is succeeded immediately by the Ripley marls of the later Cretaceous period.

At the end of the Tertiary period the mantle of loam, sands, and pebbles of the Lafayette formation was spread over the entire Coastal Plain part of the county, and it also overlapped the Paleozoic formation which underlies the extreme northern part of the county. Whether this material was deposited by virtue of a depression of the land, and the consequent invasion of the Gulf to that extent, or by fresh-water currents from the direction of the land, stimulated to greater activity by landward elevation, is unknown, but from it are derived all the soils of the Orangeburg series, the Norfolk coarse sand, and a portion of the Norfolk sand. At the close of the Lafayette period the Coastal Plain was brought to its present elevation and subjected to a great amount of erosion, by which this mantle has been completely removed in the southwestern corner of the county, where the underlying Cretaceous prairie formations give rise to the Houston black clay, and are greatly diminished in thickness everywhere.

After this period the Coastal Plain was depressed sufficiently to allow the waters of the Gulf to advance inland and deposit a mantle of sands over the marginal sea bottom. As this part of the Coastal Plain again emerged, slack waters extended up many of the streams and deposited the sediments that at present constitute the second-bottom lands. This material, reworked to some extent with the underlying clays of older formation, gives rise to the Norfolk sandy loam.

SOILS.

Eleven soil types were recognized and mapped in this area, including Meadow. The extent of each of these types and the proportion it bears to the whole area are shown in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Orangeburg sandy loam	110,144	27.5	Meadow	19,328	4.9
Orangeburg clay	69,504	17.5	Norfolk sandy loam	9,408	2.4
Norfolk gravelly loam	56,960	14.3	Houston black clay	8,576	2.2
Norfolk coarse sand	42,752	10.8	Ocklocknee clay	4,800	1.2
Lufkin clay	32,000	8.1	Total	397,440	
Norfolk sand	22,016	5.5			
Norfolk fine sandy loam	21,952	5.5			

ORANGEBURG SANDY LOAM.

The surface soil of the Orangeburg sandy loam in its typical development consists of gray sandy loam, medium to coarse in texture, from 6 to 30 inches deep, with an average of 12 to 15 inches. The subsoil is red or reddish-yellow, stiff, sandy clay to a depth of 3 feet or more. The soil varies in color from light gray to dark brown, depending chiefly upon the methods of farming which have been practiced upon it. The surface soil frequently contains a low percentage of gravel and waterworn pebbles, and small veins of such material often occur in the subsoil.

Just south of the village of Tuskegee, and also in the vicinity of Laplace, there are small areas wherein the soil is more loamy than in its typical occurrence. The soil here has a yellowish-brown cast, due apparently to the intermingling of some of the red subsoil with the sandy loam of the surface. This has given rise to the so-called "mulatto soil," which is the most productive phase of the Orangeburg sandy loam, and is considered the best upland soil in the area. This apparent mingling of soil and subsoil was due primarily to natural causes, but it has been accentuated by the more thorough methods of cultivation which have obtained on it because of its natural productivity, and therein lies the key to the most effective management of that portion of the type where the underlying clay is within 12 inches of the surface. Cultural methods should be practiced for a term of several years, whereby successive slight proportions of the clay would be incorporated each year with the surface soil. This would make the surface soil more loamy, of greater depth, less subject to injury from the prevalent droughts, and consequently more productive. This phase would have been mapped as Orangeburg loam had its area been sufficient to justify the separation.

A lighter phase of the Orangeburg sandy loam occurs in the extreme northern part of the county. It occupies the rolling country that lies along the junction of the Gulf Plain and Ashland Plateau, where the Lafayette formation overlaps the southern slope of the plateau.

The soil is a coarse sandy loam from 10 to 30 inches deep, underlain by reddish-yellow sticky sand or clayey sand. It always contains small iron concretions and small quantities of quartz gravel. but not enough to constitute a gravelly loam. The soil is generally deeper and the sand coarser than that of the typical Orangeburg sandy loam. The subsoil contains more coarse sand and iron concretions, and its color is noticeably lighter than that of the normal type. In the vicinity of the Tuskegee Normal School there is a similar variation, which seems a gradation soil between the Orangeburg sandy loam and the Norfolk coarse sand. On the slopes bordering streams in the northern part of the county occasional small areas are found over which are scattered fragments of rocks which represent portions of the overlapped strata that have been most resistant to weathering, and have been left exposed by the removal of the soil mantle above them by rapidly flowing water. These stones are quartz or gneiss fragments, varying in size from 1 to 10 inches in diameter, and never occur in sufficient quantity to prevent cultivation.

The largest area of the Orangeburg sandy loam lies just south of Tuskegee and extends thence to the western border of the county.

Many areas of lesser extent are found in the uplands throughout the county.

The type occupies country generally rolling, although level areas of considerable size occur on broad-topped hills. The rolling character of the surface secures for this type good natural drainage. The soil is somewhat prone to wash on slopes, and gullies are often formed on steep hillsides. Scrupulous care should be observed in the management of the soil to overcome this tendency.

The Orangeburg sandy loam is derived from the sandy mantle and the clays of the Lafayette formation, which covers a large portion of the area.

Cotton and corn are the principal crops on this soil, as upon all other types of the area. The yield of cotton varies from one-eighth bale to 1 bale per acre, but one-third bale per acre is probably an average yield. Efficient methods of management would largely increase this yield, and the type as mapped should produce an average yield of from one-half to two-thirds bale per acre. The "mulatto" phase of this type, already mentioned, when well farmed for a series of years, has produced from two-thirds bale to 1 bale per acre year after year, and this fact should be sufficient incentive to the owners of this type of soil to undertake to increase its rate of productivity. This could be done by adopting the methods of tillage already mentioned, gradually incorporating the underlying clay with the surface soil, and by growing leguminous crops to supply additional organic matter.

Areas of the type subjected by position to washing have suffered severely from this cause, and preventive measures should be taken, such as contour plowing and cultivation and terracing the steep hillsides.

Corn yields from 6 to 30 bushels per acre, according to the management of the land, and the average yield is not above 10 bushels. Where the type is well farmed, oats yield from 10 to 50 bushels per acre, according to the season, with an average of 30 bushels.

The Orangeburg sandy loam is adapted to cotton, corn, potatoes, clover, cowpeas, and other general farm crops. It is also the best soil in the area for the production of fruits.

The table on the following page shows the texture of both soil and subsoil of this type.

Mechanical analyses of Orangeburg sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10842	Tuskegee	Medium sandy loam, 0 to 12 inches.	2.2	16.1	15.2	21.7	20.3	17.9	6.3
10844	1¼ miles S. of Tuskegee.	Sandy loam, 0 to 9 inches.	2.3	7.6	6.6	24.2	25.3	25.2	8.7
10838	2 miles E. of Shorter	Coarse sandy loam, 0 to 15 inches.	1.6	12.3	18.2	28.1	12.1	18.6	8.9
10843	Subsoil of 10842	Red sandy clay, 12 to 36 inches.	1.9	13.8	11.7	16.1	13.7	18.1	24.4
10839	Subsoil of 10838	Red sandy clay, 15 to 36 inches.	.9	8.6	14.3	24.4	10.4	15.0	25.8
10845	Subsoil of 10844	Sandy clay, 9 to 36 inches.	.7	5.6	4.7	17.4	20.9	20.4	29.6

ORANGEBURG CLAY.

The surface soil of the Orangeburg clay, in its typical development, consists of heavy red loam or clay, with a depth of 6 inches. Frequently a shallow covering of sandy loam occurs, from 2 to 6 inches deep. When of the latter depth, the extremely shallow plowing generally practiced in the area gives to this type the appearance of a sandy loam, but if plowed to a proper depth the soil, even of this most sandy portion, becomes distinctly loamy in the course of a few years.

The subsoil has the appearance of a stiff red clay in cuts and gullies, but upon closer examination it is seen to be a mixture of clay and sand, which is shown by the mechanical analyses to be mainly of the fine and very fine grades. Such soil arrangement has given rise to the apt term "sandy clay," which sometimes is used in describing this subsoil. Certain portions of this type are termed "hog-wallow" lands. This appellative belongs more strictly to the Lufkin clay, and is mentioned further in the description of that type. Near its boundary with the Lufkin clay the Orangeburg clay is underlain frequently, at depths ranging from 1 to 3 feet, by the limestone subsoil of that type.

The largest area of the Orangeburg clay lies between Caleebee and Gubahatchee creeks, where it extends from Laplace to Cotton Valley. East and north of this area the type extends along Big Swamp Creek, and thence westward to Little Caleebee Creek. Several smaller areas are scattered over the southern half of the county.

The type occupies moderately rolling country, in which level and slightly rolling areas are not uncommon. In such areas, and in that part of the type already mentioned wherein the subsoil is the same as that of the Lufkin clay, artificial drainage would be highly beneficial, but the greater part of this soil formation has good surface drainage. Well-marked slopes are liable to suffer from washing, and care should be exercised in their cultivation to overcome this destructive tendency. The slopes should always be plowed parallel to the lines of contour, and cultivation throughout the season never should be up and down the slope. In addition, terracing will be necessary in the steepest places, if they are to be cultivated to advantage.

The Orangeburg clay is derived from the Lafayette formation.

That part of the type which has a shallow covering of sand is cultivated as generally as any of the upland soils of the county, and produces yields of cotton and corn comparable to the methods employed. It should produce excellent crops with better and more thorough methods. Where the sandy covering is lacking the type is seldom farmed, because it is hard to work and requires thorough tillage. If this soil were plowed deeply and worked carefully with efficient implements only at times when moisture conditions were favorable, remarkable yields could be secured. Such tillage is not practiced, and as a result relatively little of this soil is cultivated. The type is well adapted to the production of cotton and other general farm crops.

The following table shows the results of mechanical analyses of both soil and subsoil:

Mechanical analyses of Orangeburg clay.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10650	4 miles S. of Tuskegee	Brown clay loam, 0 to 8 inches.	1.0	2.3	1.7	12.7	28.6	30.1	23.6
10648	4 miles W. of Liberty Hill.	Red sandy loam, 0 to 6 inches.	1.5	5.2	4.3	14.3	21.5	20.9	31.8
10646	2 miles N. of Warriorstand.	Red heavy clay, 0 to 6 inches.	.6	1.6	1.4	19.1	19.9	12.1	44.9
10649	Subsoil of 10648	Red sandy clay, 6 to 36 inches.	1.1	4.2	3.8	15.4	20.4	22.6	32.5
10651	Subsoil of 10650	Red clay, 8 to 36 inches.	.6	1.4	1.2	7.7	18.9	26.9	42.6
10647	Subsoil of 10646	Red heavy clay, 6 to 36 inches.	.2	.8	.6	13.1	18.3	10.3	56.7

NORFOLK COARSE SAND.

The surface soil of the Norfolk coarse sand consists of medium to coarse sand, which is slightly loamy to an average depth of 8 inches. The subsoil consists of similar material, which generally becomes coarser in texture with increasing depth, until it rests upon a bed of coarse gravel. Fine gravel occurs throughout soil and subsoil, and the latter often contains iron crusts. From 10 to 60 per cent of coarse gravel is strewn over the surface of small areas. The materials composing this type, to a depth of several feet, are loose and incoherent and very unretentive of moisture. The depth of such material depends largely upon the location.

The Norfolk coarse sand is found in an irregular band along the upland to the south of Uphapee Creek, and it also occurs in a large body between Chowocala and Chewockeleehatchee creeks, including the districts near Pleasant Hill, Alliance, and Little Texas. Both of these areas are moderately rolling upland, which is frequently marked by long, narrow ridges and small hills. Such topography accounts for the variable depth of this soil. The flattest portions of the upland have the deepest subsoils, which often consist of coarse sand and gravel from 10 to 15 feet deep. In areas along stream slopes erosion has left exposed, in many places, the underlying gravel formations. Small flat areas, bordering minor stream courses, usually grade into a heavy subsoil at 3 feet. This regulates their water supply, and crops are grown successfully on these limited areas. The topography of the Norfolk coarse sand is such as to give good surface drainage. In addition, the porosity of the soil to a depth of several feet is so great that the type is extremely susceptible to drought, and there are few seasons when crops do not suffer from lack of moisture.

The Norfolk coarse sand is derived from the Lafayette sands, which, in the areas occupied by this type, usually are underlain by the older sandy formations.

The crop yields on this type are very low. The average yield of cotton does not exceed one-sixth bale per acre. On some plantations, under favorable conditions, the average yield is somewhat larger, but this is exceptional. The average yield of corn is not more than 6 or 8 bushels per acre. Sweet potatoes of excellent quality often yield from 35 to 70 bushels per acre, although few are grown except for home use. Peaches and cherries thrive on this soil, but the trees are short lived.

Early truck crops might be grown on the areas of this soil least susceptible to drought, but there is not sufficient demand to warrant the development of this industry. The greater part of the Norfolk coarse sand is not tilled. It is the poorest soil in the area, and so long as much better land may be had but a few miles distant at the low prices which prevail at present this type should not be farmed at all.

The subjoined table gives the texture of the fine-earth portion of both soil and subsoil of this type:

Mechanical analyses of Norfolk coarse sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10866	5 miles W. of Society-hill.	Gray gravelly sand, 0 to 10 inches.	7.0	15.3	13.1	31.1	16.1	11.7	5.2
10868	2 miles E. of Tuskegee.	Gravelly sand, 0 to 8 inches.	5.7	22.7	15.3	23.6	11.9	15.4	5.5
10864	Near Pleasant Hill	Sand and gravel, 0 to 8 inches.	4.9	19.6	13.5	25.2	13.2	10.7	12.8
10869	Subsoil of 10868	Gravelly sand, 8 to 36 inches.	7.3	22.0	14.8	22.4	14.1	14.4	4.6
10865	Subsoil of 10864	Sand and gravel, 8 to 36 inches.	6.1	14.8	13.1	26.6	12.8	15.9	10.1
10867	Subsoil of 10866	Coarse gravelly sand, 10 to 36 inches.	4.8	16.0	12.4	27.1	14.2	15.2	10.3

NORFOLK GRAVELLY LOAM.

The surface soil of the Norfolk gravelly loam is a gray, coarse to medium sandy loam from 6 to 30 inches deep, containing from 15 to 50 per cent of gravel and iron concretions. The subsoil varies from a sticky sandy loam to a light sandy clay, with the admixture of varying amounts of gravel. The gravel content generally is mixed evenly throughout soil and subsoil, but occasionally the surface is strewn with coarse gravel, though the underlying soil may have but the normal gravel content; and, again, the subsoil may contain veins and pockets of coarse gravel. Fragments of coarse, ferruginous sandstone are of frequent occurrence. This type is distinctly lighter than the Orangeburg sandy loam, is much more susceptible to drought because of its more open texture, and is naturally less productive.

The Norfolk gravelly loam is located in the rolling country to the north of an east and west line drawn through Tuskegee. It is thus closely associated with both the Norfolk coarse sand and the Orangeburg sandy loam.

It has the same topographic characteristics as the other upland soils of the country—gently to steeply rolling areas, marked with occasional ridges and hills. Such surface features, combined with its mellow texture, secure for this type excellent drainage.

Near the county line, west and north of Notasulga, is found a variation of this type. This variation occurs near the contact of the metamorphic rock formations, which lie to the north, and the overlying deposits of the Lafayette. Possessing chiefly the characteristic materials of the Lafayette, metamorphic stones and bowlders are abundant in the road cuts, and are scattered over the surface. These rocks, by their decay, have played some part, also, in determining the character of the soil and subsoil, which contain much less sand than in typical areas, and accordingly are much more plastic.

North of the Tuskegee Normal School, and including part of the farm lands of that institution, there is a considerable area which passes very gradually from Norfolk gravelly loam to Norfolk coarse sand, and for some distance the soil resembles each type.

The Norfolk gravelly loam is derived from the sandy mantle and the clays of the Lafayette formation. Much of the area occupied by this type is uncultivated at present, and supports a scattered growth of oak and pine.

The yields obtained on the greater part of the cultivated areas are low, as the average crop of cotton is not above one-fourth bale, and that of corn not more than 12 bushels, per acre, when from 150 to 200 pounds of commercial fertilizer are applied.

The Norfolk gravelly loam is not as productive as the Orangeburg sandy loam, but with better methods should produce fairly satisfactory crops of cotton, corn, cowpeas, sweet potatoes, and truck crops. For the production of peaches it is probably the best soil of the area.

The texture of the fine-earth portion of the soil and subsoil of this type is shown in the following table:

Mechanical analyses of Norfolk gravelly loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
10632	Near Tuskegee Normal School.	Coarse sandy loam, 0 to 15 inches.	10.6	24.7	17.1	24.6	9.0	7.8	6.2
10636	E. of Uphapee Creek...	Sandy loam, 0 to 12 inches.	8.2	18.7	13.1	24.2	16.8	11.4	7.0
10630	4 miles E. of Milstead..	Medium sandy loam, 0 to 12 inches.	10.6	24.5	13.9	19.2	13.8	9.9	8.0
10637	Subsoil of 10636..........	Red sandy loam, 12 to 36 inches.	10.8	23.2	11.7	15.2	8.9	9.7	20.0
10631	Subsoil of 10630..........	Clay loam, 12 to 36 inches.	8.1	22.2	11.4	14.5	9.1	9.1	25.1
10633	Subsoil of 10632..........	Red sandy clay, 15 to 36 inches.	5.3	18.6	12.2	17.9	5.7	9.2	30.7

NORFOLK SAND.

The surface soil of the Norfolk sand consists of 3 feet or more of coarse to fine sand, with a slight admixture of finer material. The type does not occur in large areas, but is found in three distinct positions which have an important effect upon its productivity.

The coarsest phase occupies upland areas which are somewhat broken by low hills and ridges. The soil of such elevations is coarser than the true type, because of the tendency of the finest portions to wash down the slopes. The Norfolk sand of this description is a very poor soil, and is seldom cultivated.

On flat upland areas, which, from their position, do not suffer from erosion, the soil is finer in texture and is colored dark by the accumulation of organic matter. Such areas sometimes are underlain by clay at a depth of 3 feet, which renders them less susceptible to drought.

This phase of the type, as well as the preceding one, is derived from the Lafayette mantle. It is generally cultivated, and yields from one-sixth to one-third bale of cotton and from 6 to 12 bushels of corn per acre, depending upon the methods employed in its management.

The Norfolk sand is also found to a limited extent on stream terraces, where it is sedimentary in origin. The soil of such areas consists of medium and fine grayish sand to a depth of 30 inches or more. This is underlain by sticky sand, which grades into a plastic, drab-colored clay loam, at depths varying from 3 to 3½ feet. The soil in this position is subject to inundation when the largest streams overflow their banks, but the damage from this source is insufficient to make cultivation unprofitable. An average yield on this phase of the type is one-third bale of cotton or 10 bushels of corn per acre.

The following table shows the results of mechanical analyses of the type:

Mechanical analyses of Norfolk sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10826	½ mile W. of Warrior-stand.	Medium sand, 0 to 8 inches.	0.7	8.4	10.9	67.3	10.7	4.3	2.2
10828	2 miles N. of Calebee...	Medium sand, 0 to 6 inches.	5.2	18.3	16.7	35.8	13.2	6.1	4.3
10827	Subsoil of 10826..........	Medium sand, 8 to 36 inches.	.2	2.3	6.8	62.5	15.3	7.8	4.6
10829	Subsoil of 10828..........	Medium sand, 6 to 36 inches.	3.6	16.9	16.8	37.2	12.5	7.6	5.2

HOUSTON BLACK CLAY.

The surface soil of the Houston black clay is black or drab clay from 6 to 10 inches deep. This is underlain by very stiff drab or yellow clay, which becomes waxy and sticky when wet. Numerous shells and carbonate of lime nodules are found in both soil and subsoil, but in the latter they are the more abundant. The subsoil also contains occasional pockets of rounded quartz pebbles. When in a moist condition the surface soil is very sticky, and on drying it becomes extremely hard and cracks into irregular blocks.

The Houston black clay occupies but a small area in the southern part of the county. It is known locally as the "black prairie land," because of the color of the greater part of the surface soil. It is nearly level and is treeless, save along some of the sloughs which mark its surface. The type, as a whole, is not well drained. Surface drainage is sluggish, because the topography is level, or but slightly undulating, and the subsoil is very impervious to moisture. The construction of drains involves much tedious labor because of the stiff character of the subsoil. As a result of its texture, the soil is quite susceptible to injury from excessive rainfall, while it is also severely affected by droughts.

The Houston black clay is derived from the disintegration of the rotten limestone, or Selma chalk formation, which was deposited as a sediment in the deep or open sea which prevailed at this point during the greater part of the Upper Cretaceous period.

Cotton and corn are the principal crops grown. An average yield of the former, when well farmed, is one-half bale per acre; but the latter, without fertilization, yields only from 10 to 15 bushels. Johnson grass has been grown to a limited extent on this soil, and good yields are obtained, but many object to sowing it because of the difficulty encountered in eradicating it for the cultivation of subsequent crops. The successful growth of this grass, however, makes possible the development of the cattle industry, if at any time the price of cotton should be so low as to make the production of that crop unprofitable.

The results of mechanical analyses of the soil and subsoil of this type are given in the following table:

Mechanical analyses of Houston black clay.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10820	¼ mile S. of Edwards	Gray clay loam, 0 to 9 inches.	0.7	1.4	1.8	9.5	22.1	51.6	12.9
10822	Near Downs	Black sticky clay, 0 to 4 inches.	.2	.4	.4	5.0	17.9	54.5	21.7
10824	1 mile E. of Downs	Gray clay loam, 0 to 6 inches.	.5	1.3	.7	4.8	11.2	50.0	31.7
10823	Subsoil of 10822	Black heavy clay, 4 to 36 inches.	.2	.5	.8	3.2	12.6	60.2	22.5
10821	Subsoil of 10820	Gray clay, 9 to 36 inches.	1.0	1.8	1.0	4.9	9.0	46.2	35.5
10825	Subsoil of 10824	Gray sticky clay, 6 to 36 inches.	.4	.8	.6	5.0	7.4	41.4	44.0

LUFKIN CLAY.

The surface soil of the Lufkin clay is a heavy red or reddish-yellow clay loam, which is extremely plastic when wet. This is underlain by soapy red or yellow clay, which often contains nodules of lime. Beneath this the underlying beds of rotten limestone are often exposed in cuts, and above the limestone quantities of small shells are of common occurrence.

This type occupies the so-called lime hills, and represents a transition soil between the Houston black clay of the prairie and the Orangeburg series, which extends northward to the metamorphic rock formations, and hence is found only in the southern part of the county. Wherever the accumulation of the Lafayette formation covers this type to a depth of 12 inches or more it has been mapped with the Orangeburg series. Part of the so-called " hog-wallow " soils have been included in this type. The composition of these soils is such that when wet they are inclined to " run together," and this tendency makes them very difficult to cultivate. In wet seasons they are often abandoned.

The Lufkin clay is so poorly drained, because of its impervious texture, as to preclude any possibility of a good crop in a wet season. The value of the type depends upon artificial drainage, and such drainage would be too expensive to be practicable at the present low price of land in this section.

This type is derived from the intermingling of the soil resulting from the decomposition of the hard, sandy limestone of the Ripley group with the Lafayette formation, and partakes in varying degree of the characteristics of both. The timber growth on this soil is chiefly post oak, and for this reason it is called " post-oak prairie."

The Lufkin clay is a very unpopular soil. It is commonly said to be " too wet, or too dry, and too hard to work." Few whites live upon it, and the negroes dislike to farm it because it is so hard to till. Under such conditions the major part of the type is uncultivated. When tilled, good crop yields are obtained in dry seasons, but in wet seasons it is practically impossible to work this soil, and partial or total failures are common. In dry seasons this type gives larger crop yields than the Orangeburg clay, but succumbs to excessive rainfall much sooner even than that type. At present cotton yields from one-fifth to one-half bale per acre.

Whenever the increase in the value of land shall warrant the expense of underdraining, this soil will be very productive if well farmed. Until that time crop returns will be uncertain, because of its susceptibility to seasonal extremes of moisture.

The table following shows the results of mechanical analyses of both soil and subsoil of this type.

Mechanical analyses of Lufkin clay.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10362	1¼ miles E. of Chesson.	Brown loam, 0 to 8 inches	0.3	1.4	1.2	17.1	29.2	32.1	18.8
10360	2 miles E. of Hardaway.	Red heavy clay, 0 to 8 inches.	.6	.8	.3	2.6	15.1	16.3	64.3
10363	Subsoil of 10362	Gray tenacious loam, 8 to 36 inches.	.1	1.1	3.0	22.5	20.3	34.5	17.9
10361	Subsoil of 10360	Heavy plastic clay, 8 to 36 inches.	.5	.7	.3	3.3	15.0	16.0	64.3

NORFOLK SANDY LOAM.

The surface soil of the Norfolk sandy loam, to a depth of from 8 to 12 inches, is a brown loamy sand or sandy loam, which frequently contains a small percentage of fine gravel. This is underlain by yellow clay loam, or sandy clay, to a depth of 36 inches. Coarse gravel frequently occurs on the surface in spots which may be a few acres in size, but there is seldom any gravel in the subsoil. The type occurs as level or very gently rolling bottom lands along Uphapee Creek and its tributaries. Sometimes in the winter most of the type is overflowed, and the lower portions occasionally suffer from inundations during the summer.

The soil owes its origin to the reworking of the Pleistocene sands with the underlying clays of the older formations.

This soil is farmed to cotton and corn, the staple crops of the area, and, in comparison with the upland types, produces good yields of each in favorable seasons. Accurate estimates of crop yields were not obtainable, but it is not so productive as the Norfolk fine sandy loam or the Ocklocknee clay.

The following mechanical analyses show the texture of both soil and subsoil:

Mechanical analyses of Norfolk sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10352	3 miles E. of Chehaw.	Light sandy loam, 0 to 9 inches.	8.5	17.8	11.6	17.2	15.1	19.2	10.4
10354	Near Tuskegee	Light sandy loam, 0 to 9 inches.	2.7	15.7	10.5	14.7	29.1	14.1	13.1
10353	Subsoil of 10352	Sandy clay, 9 to 36 inches	6.1	17.8	10.4	14.7	12.2	17.9	20.7
10355	Subsoil of 10354	Sandy clay, 9 to 36 inches	2.6	14.8	10.3	12.4	21.3	15.7	22.3

NORFOLK FINE SANDY LOAM.

The surface soil of the Norfolk fine sandy loam consists of gray fine sandy loam or fine sand, which sometimes is colored black with organic matter to a depth ranging from 10 to 30 inches. This grades into yellowish or gray clay loam, which contains varying amounts of fine and very fine sand.

Along Persimmon Creek are several small areas which are similar to the Calcasieu fine sand. The surface in such places is marked by small mounds from 10 to 18 inches high. The soil consists of fine sand from 18 to 30 inches deep, underlain by a few inches of sticky sand, which grades into mottled clay loam. The soil grades very gradually from the center of these mounds into the typical fine sandy loam which surrounds them.

Another variation occurs along Caleebee Creek, where the soil is a fine dark-brown loam, which is very sticky when wet. The subsoil is a sticky, slightly loamy fine sand. This type is a low-lying, flat, stream-marginal soil, and produces excellent yields of cotton and corn.

The Norfolk fine sandy loam is found only in the southern part of the county, where the principal areas occupy first terraces along the upper courses of Caleebee, Gubahatchee, Line, and Old Town creeks, and the lower courses of their tributaries. It is subject to overflow, and crops are liable to injury from this cause. Serious damage to crops occurs every few years, but the natural productivity of the soil in favorable years is more than sufficient to offset the liability to loss in wet seasons.

The type is so level that certain portions need draining. This is done by means of open ditches, and with this provision the type generally is well drained in favorable seasons.

The Norfolk fine sandy loam is derived from the fine grades of sand which have been washed from the adjacent uplands. This material has been deposited upon the sedimentary clays and loams which were laid down in the estuaries during the time of the Pleistocene submergence. This is the typical sandy hammock land of the area. In places where the rate of current was retarded during overflow by topographic obstruction, finer material, brought from upstream during times of high water, was deposited in shallow water, which was comparatively quiet, and thus were formed the small areas of the black hammock phase of this type.

Cotton yields from one-half to 1 bale per acre, and corn from 20 to 35 bushels per acre, in favorable seasons. The best staple of cotton grown in the area is obtained on this type. Its excellence as a cotton soil prevents other crops from being grown upon it to any considerable extent, but good crops of oats are often obtained when the price of cotton is low. Care should be taken, however, to break the continuity of cotton production by the introduction of other crops in rotation.

The texture of the soil and subsoil of this type is shown in the following table:

Mechanical analyses of Norfolk fine sandy loam.

No.	Locality.	Description.	Organic matter.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10318	6 miles S. of Tuskegee.	Fine loamy sand, 0 to 24 inches.	0.7	0.0	0.0	0.1	26.7	55.5	12.7	4.4
10316	3 miles S. of Laplace.	Fine sandy loam, 0 to 18 inches.	1.1	.0	.9	1.1	17.2	45.3	28.8	6.2
10317	Subsoil of 10316 ..	Gray clay loam, 18 to 36 inches.	.5	.1	1.1	.9	14.9	40.5	26.1	15.8
10319	Subsoil of 10318 ..	Fine sandy loam, 24 to 36 inches.	.6	.0	.0	.4	20.6	40.5	16.7	21.4

OCKLOCKNEE CLAY.

The surface soil of the Ocklocknee clay is a rich, dark brown or black loam, or heavy fine sandy loam, which often contains a considerable proportion of silt.. This rests upon a lighter brown or drab loam, which is somewhat heavier in texture than the soil, and generally grades into a heavy plastic clay loam or clay at a depth of 30 inches or more. The presence of flakes of mica in both soil and subsoil is general.

The type occupies a comparatively small area in the northwestern part of the county, along the Tallapoosa River. The largest area extends from just west of Milstead to Line Creek, which marks the boundary between Macon and Montgomery counties. The subsoil of this type, which is typical in the eastern part of the above-mentioned area, grows heavier very gradually, following down the course of the Tallapoosa River until, near Line Creek, it becomes a heavy, plastic, drab-colored clay loam. This same character of subsoil extends some distance up Gubahatchee Creek. The soil, also, along that creek is heavier than in its typical development.

West of Cole Station, along the Tallapoosa River, elevations of extremely fine sand, which seldom exceed a height of 10 or 12 inches, mark the surface of this type. The subsoil of this area contains more very fine sand than is found in the larger area farther down the river.

The high bottom lands occupied by this type are very flat, and sometimes are overflowed during the winter season, but inundations during the crop season are exceptional. The topography is so level, however, that most of the type requires ditching to secure adequate drainage.

The Ocklocknee clay is an alluvial soil, derived chiefly from the decomposition products of the metamorphic material which borders the area on the north. This material has been brought down during flood time and deposited as alluvial flats along the course of the river and the lower reaches of its tributaries.

The Ocklocknee clay occupies one of the most productive bottoms of the area, and good crop yields are always secured, except in abnormally wet seasons. In favorable seasons cotton yields from one-half bale to 1 bale per acre, with an application of 200 pounds of commercial fertilizer, and corn yields 40 bushels per acre without the use of fertilizer.

The following table shows the results of mechanical analyses of this type:

Mechanical analyses of Ocklocknee clay.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10358	2½ miles W. of Milstead.	Fine sandy loam, 0 to 22 inches.	0.1	0.5	1.0	21.2	23.1	36.3	17.8
10356	2 miles W. of Milstead.	Dark clay, 0 to 20 inches	.0	.5	.6	2.8	8.4	50.4	36.6
10359	Subsoil of 10358	Dark clay loam, 22 to 36 inches.	.0	.5	1.4	9.7	17.2	43.3	27.2
10357	Subsoil of 10356	Yellow micaceous clay, 20 to 36 inches.	.0	.3	.9	8.1	10.1	39.4	41.0

MEADOW.

The Meadow of Macon County consists of low-lying, nearly flat areas adjacent to stream courses, which are overflowed to such an extent that they are almost continually in a condition too moist for cultivation. Many of these areas never have been cleared, and support a growth of water-loving trees, while others are occupied by small bay swamps. Very little of this type is ever tilled.

AGRICULTURAL METHODS.

The methods of cultivation followed in Macon County do not differ essentially from those in general use in this section of the South. Land is so plentiful, because of sparse population, that soils easily tilled are the most sought, and extensive tracts are not tilled at all. Most of the upland types of soil are mellow and easy to work, and it is very rare that any land is sodded.

There is little variation in methods of tillage. Little plowing is done in the fall, though probably it is the preferable time for the heavy and rough soils. The land is broken in the winter or early spring to a depth of 3 or 4 inches, with a small one-horse plow. On the bottom lands and on the stiff upland soils the use of a disk harrow after plowing is highly beneficial, but comparatively few are used. The soil on the sandy types is so loose and mellow that further working is considered unnecessary. If cotton is to be planted, the land is so turned as to form narrow beds. Fertilizer is applied at the rate of from 100 to 600 pounds per acre, and the seed is dropped with a one-horse planter. Cultivation is continued throughout the season by the use of single plows. While crops are cultivated sufficiently to keep the weeds down, the best farmers cultivate cotton from five to seven times, while probably more than one-half the acreage is cultivated but two or three times. In general, shallow cultivation should be given after each rain, and as often as possible at other times.

Cotton is the one important crop, and consequently the product of almost sole consideration. The only method of cropping, or of rotation, is to plant as much cotton as possible. The low price of that staple, or other circumstances, may make it necessary to raise sufficient corn and other crops for home use, but the feeling seems prevalent that such secondary crops are, at best, but necessary evils. After the war money had to be advanced to the majority of farmers to enable them to grow their crops for the year, and as cotton was the sole money crop, it was grown to the exclusion of all other crops in order to give security to the one who had advanced the money. This custom, inaugurated by necessity, was a serious handicap for many years to the development, or even the maintenance, of agricultural interests, and few were able before 1880 to resume the custom of producing their own provisions. Examples worthy of emulation are not infrequent, for the most thrifty farmers make a practice of producing sufficient supplies for home use and then growing as much cotton as possible for the money crop. The greatest mistake made by most of the negroes and by many of the white people is to place entire dependence upon cotton and plan to buy the chief part of their supplies for subsistence.

Very few cattle are kept in the county, and little effort is made to save the small amounts of manure which might be had. Formerly the chief dependence was placed upon cotton seed for fertilizer, and smaller amounts of commercial fertilizer were used than at present. The increase in the price of cotton seed, however, has caused more of it to be sold, until now more than half the farmers use a cheap grade of commercial fertilizer, at an average rate of 200 pounds per acre. The remainder use similar amounts of a compost made of 200 pounds of acid phosphate and 100 pounds of cotton-seed meal, or apply the cotton seed intact, sometimes destroying its germinative properties by the use of steam.

Corn usually is planted on lands which produce the poorest yields of cotton. It receives little attention in cultivation until cotton is cared for, and the yields are low. The excess of the acreage of cotton over the combined acreage of other crops precludes the possibility of regular rotation, and cotton frequently is grown on the same field from five to twenty years in succession. The best farmers make some effort to rotate crops, but they are unable to follow a perfect system because of the large acreage of cotton. One of the most successful rotations practiced is oats mowed while still in the milk for hay, followed by cowpeas the same season, succeeded by cotton and corn the next year, when cowpeas may be sown in the corn at the last cultivation. Oats are considered somewhat exhaustive to the land, but the roots of the cowpeas following the same season more than make up for this and leave the land in good condition for cotton. Rust-proof oats only can be grown here.

In Bulletin No. 81 of this Department, Professor Tracy advocates, for areas where two-thirds or more of the land is used for cotton, with no permanent hay fields, the following rotation: "First year, cotton; second year, corn and cowpeas and winter oats and vetch; third year, cotton. The corn should be planted as early as possible, and at the last cultivation cowpeas should be sown between the rows. The crop can be harvested by September, when the ground should be sown at once with a mixture of turf oats and hairy vetch. The oats and vetch will grow throughout the winter, furnishing excellent winter grazing, or they may be cut for hay in April in time for planting cotton again."

It is extremely unfortunate for the best development of the area that conditions are such as to militate to no uncertain degree against the adoption of definite and regular crop rotations. There is no doubt that in a period of ten years more cotton can be obtained from a given field if rotated with other crops at least twice than if the field were planted to cotton for ten successive years, and, furthermore, the products of the other crops would be clear gain. Better systems of crop rotation must be adopted if the agricultural resources of the county are to be developed to a degree commensurate with their natural possibilities.

AGRICULTURAL CONDITIONS.

At no time during the last ten years has the condition of the farmers of Macon County been so prosperous as at present. The striking success of a few and the more valuable examples of others whose progress has been slow and steady, while overcoming adverse circumstances and conditions such as the average farmer of this region has to meet, show clearly that constant and consistent effort, supported by intelligent conduct of business, are the chief requisites here for successful farming.

It can not be said, however, that the farming class, considered as an entirety, is prosperous. Several causes have contributed to this condition. The price of cotton, which until recently had been generally low for several years, is ascribed commonly as the all-potent reason. This view would be correct if it were necessary to adhere strictly to the agricultural methods, more or less slack and improvident, which have been the rule rather than the exception, but lack of energy, indifference to improvement of methods, and the failure to adjust farming operations to changed conditions play a no less important part in the general welfare of the farming class. Many became so reduced financially in years of unprofitable production of cotton that, at best, recovery could be but slow. This discouraged many who have been drifting along hoping for better times, yet hardly ready to avail themselves of the possibilities which improved conditions have brought.

There are but few farmers in the county who have sufficient capital to manage independently their yearly business. Fortunately, the system of loaning followed here is much better adjusted than in some other counties in the State. Few white farmers buy of merchants on credit, but instead are furnished with money by their banks, at a stated rate of interest, with which they pay cash to merchants for supplies. This method, although the rate of interest can not be low, is found in actual practice to be by far the most economical plan for the farmer.

The tenure of farms varies in different sections of the county. North of the latitude of Tuskegee 75 per cent or more of the landowners live on and till their own farms. South of this line at least 75 per cent of the landowners live in Tuskegee or some other town and rent their land to tenants. In the southwestern corner of the county not less than 90 per cent of the landholders are nonresident, many of them living in Montgomery. The tendency which has prevailed for some time for the white farmer to move to town and to rent his farm under some system of tenantry is one of the most serious problems with which this section has to cope.

The share-tenant system is the usual method of renting land, whereby the owner furnishes the land, the work animals, one-half of the fertilizer, pays one-half the bill for ginning, and receives one-half of the crop, while the other half goes to the tenant for labor and feeding the work animals.

Another method of rental in common use is for the renter to pay a stated amount of cotton for the use of the land. The rate usually paid is 1 bale for about 25 acres, from which the average crop is 3 to 4 bales. To this entire area the renter applies about 1 ton of commercial fertilizer, which he has bought on credit. General supplies are also obtained on credit. Rent is a preferred claim, and in unfavorable seasons the entire crop is barely enough to pay it. The landlord often sells the tenant his provisions and takes a lien on the crop as security. In an average year the renter can pay his obligations, but seldom has anything left. "Advancing" to tenants under such a system involves great risks, and the landlord or merchant who advances must exact a rate of interest which at first sight seems excessive, to make good the losses sustained from shiftless tenants. By such methods a large percentage of the tenants are left in debt at the end of the year, and begin a new year under similar arrangements, hampered by the obligations of the preceding season. In favorable seasons the tenant might save some money, but it is usually squandered before spring. Even the cotton seed which has been saved for the next season's crop is often sold during the winter, and the tenant has nothing with which to plant the next crop until it is "advanced" to him.

Land holdings vary much in size, ranging from 50 acres to 17,000 acres, but the greater part of the county is divided into farms containing from 100 to 500 acres each. Farms are not as large in the northern part of the county as in the southern part, where most landowners rent several hundred acres to negroes in parcels of 25 to 30 acres each. Real estate is seldom subjected to mortgage because small, risky loans can not be obtained at the legal rates of interest, and resort is had to notes with personal security.

Much complaint is heard throughout the county about the inefficiency of labor, and frequently the statement is made that conditions are growing steadily worse.

For a long time Macon County has depended chiefly on cotton as its export crop, and all other farming operations have been subservient to its production. The staple of cotton classed as "middling" includes the bulk of the crop, but high grades of middling are produced in favorable years. Of the soils mapped the Norfolk fine sandy loam yields the best staple. Unfortunately, no special price is paid in the local market for the highest grade of middling cotton, and thus sufficient incentive to try to improve the staple is lacking. Experiments being conducted within the area at the present time, however, give much promise as to improvement in the length of staple, and definite conclusions from these experiments are awaited with much interest.

Corn is the crop of second importance, but the yields obtained are needlessly low. The fact that a poor field of Norfolk gravelly loam, not only lighter in texture than the average of that type but lighter also than the average upland soil of the country, has been brought, economically, and within a few years, from a gullied, nonproducing condition to yield 40 bushels of corn per acre should prove a valuable lesson to the large class of farmers who obtain yields of from 6 to 15 bushels per acre. The common belief that only low yields of corn can be grown here has been shown to be erroneous, and although it may be impossible or impracticable to obtain yields to compare with those of a higher latitude, sufficient example and proof are at hand to demonstrate conclusively that this section should grow corn sufficient for its own needs. This is true not only because corn may be grown at a profit when fitting methods are followed, but also because corn is needed in the crop rotation necessary to successful farming in the area.

Little wheat is produced in the county. Rust has been very troublesome, and, although less prevalent on the sandy types of soil than on the heavier soils, the growing of wheat is of doubtful economy. Rust-proof oats are the only kind that can be grown successfully. Clover is a risky crop under the present methods of farming, but if the ground were thoroughly prepared it is probable that a fair stand could be secured. Successful crops have been grown in the county, even under very ordinary conditions, and this is enough to indicate that it should be tried by those who are willing to make the necessary effort to produce it. Sweet and Irish potatoes are grown for home use, but they can not be important crops at present on account of the distance from markets and high freight rates. Peaches, cherries, and grapes for home use and the local markets are raised successfully on the sandy soils. Enough apples are grown to supply partially the home market, but the area is not suited to their production.

Practically no attention is paid to the adaptation of soils to crops. Bottom lands seem to be preferred for the production of all crops, while of the upland types the sandy soils, which are easy to till, are chosen and the heavy clay soils are avoided. With the exception of sugar cane, the same crops are grown on all the soils.

The Seaboard Air Line Railway crosses the southern part of the county, and the Western of Alabama Railway the northern part. From Chehaw, a station on the latter road, a branch railway extends to Tuskegee, a distance of 5 miles. Freight rates are so high as to place a practically prohibitive tariff on the shipment of any farm products except cotton, and the cost of supplies brought into the county is increased in similar ratio.

On the heavier soils in the southern part of the area the public dirt roads become very muddy and nearly impassable at times during the winter, but in the summer they are in good condition, except immediately after a rain. In the upper part of the county, on the more sandy soils, the roads are always passable, but ill-suited to heavy hauling at any time.

The population of Tuskegee, the county seat and only town of importance in the area, is 2,170. Many of its residents own farms, and hence there is almost no local market within the area. Montgomery, the nearest city of importance, is 18 miles from the county line and 40 miles from Tuskegee, and affords very little market for Macon County products. The distance from markets and the high freight rates are serious obstacles to the agricultural development of the area.

SOIL SURVEY OF SUMTER COUNTY, ALABAMA.

By WILLIAM G. SMITH and F. N. MEEKER.

LOCATION AND BOUNDARIES OF THE AREA.

Sumter County lies in the west-central part of Alabama, the State line forming its western boundary. Its eastern boundary, which is extremely irregular, is formed by the Tombigbee—a very crooked river. On the south lies Choctaw County, and on the north Pickens County. Sumter County is 47 miles long, from 9 to 33 miles wide, and has an area of approximately 900 square miles. It lies within the physiographic province known as the Gulf Coastal Plain, which is popularly known as the agricultural section, in contradistinction to the northeastern two-fifths of the State, called the mineral region.

This soil survey was made by plane-table surveying—the road map and location of the different soil types having been made together as the field work progressed. The original land survey maps (1830–1832), on record at Livingston, the county seat, were referred to in making up the township and section lines.

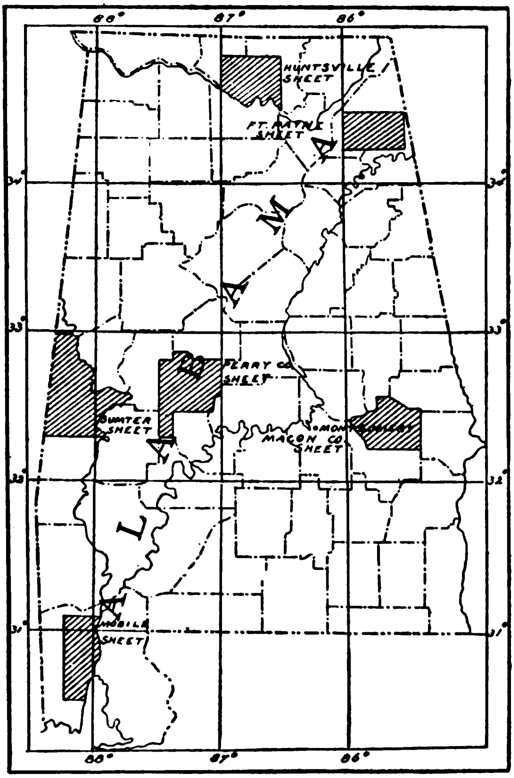

FIG. 12.—Sketch map showing location of the Sumter County area, Alabama.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The section including Sumter County was ceded to the National Government by treaty with the Choctaw Indians, September 27, 1830. A survey of the land into townships and sections was at once begun, and the land was sold to settlers. In a comparatively short time white settlement was well advanced, and on December 18, 1832, Sumter County was organized.

The early settlers came mainly from the South Atlantic States, many coming from central and eastern North Carolina.

The agriculture practiced by the pioneers did not differ much from that of the Indians, for they, too, grew corn and potatoes for domestic consumption, and depended for their meats largely upon game, which was then plentiful. By 1840, however, considerable attention was given to growing cotton. The plantations were located mainly along such navigable streams as the Tombigbee River, and by 1860 some large plantations were being operated, having as a part of their working force from 50 to 500 negro slaves. The changes wrought by the civil war, of course, checked any further agricultural development by deranging labor conditions, and many of the large estates have been divided. During the last two decades, however, marked activity has taken place in lumbering, followed by increased activity in agriculture and the development of special interests in small fruit and truck growing.

CLIMATE.

The climate is that of the warm Temperate Zone of the United States. The winters are short and mild, the summers long and warm. This condition admits of a wide range of crops, and gives a long period for tilling the soil. Crops of some sort can be grown almost the year around.

The range of temperature for the year is from 20° F., in winter, to 100° F., in summer. The average winter temperature is about 40° F., and that of summer about 80° F. The high relative humidity frequently prevailing serves, however, to intensify the sensation of cold or heat, and from June to September there are often long periods of oppressively hot weather.

The soil seldom freezes to a depth of more than an inch or so, and then only for a few hours, or at most days. Snow seldom falls, and when it does it soon melts away.

The average date of the last killing frost in spring is March 12, and of the first killing frost in fall, November 8.

The annual precipitation is about 50 inches. Most of the precipitation comes during the winter, spring, and early summer months, averaging from 4 to 5 inches a month, while during September, October, and November, or the period during which the bulk of the cotton crop is ready for picking, the precipitation amounts to only about 2 or 3 inches a month. The rainfall is usually so well distributed that serious droughts are seldom experienced. The rainfall in summer is usually in the form of showers of short duration. On the other hand, long-continued rains in winter and spring sometimes result in seriously washing and gullying the hilly areas, and in flooding the stream bottoms and level uplands.

The following table, made up from the Weather Bureau records, includes stations which are believed fairly to represent the climatic conditions of Sumter County. It shows the normal monthly and annual temperature and precipitation:

Normal monthly and annual temperature and precipitation.

Month.	Meridian, Miss.		Livingston, Ala.		Pushmataha, Ala.		Newbern, Ala.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	° F.	*Inches.*	*° F.*	*Inches.*	*° F.*	*Inches.*	*° F.*	*Inches.*
January	47.0	5.15	....	4.00	45.7	4.80	45.4	4.40
February	53.6	5.81	49.0	4.78	49.0	5.72	47.2	5.55
March	54.5	5.55	55.8	5.14	57.9	5.81	56.8	5.10
April	65.6	4.37	64.8	3.07	64.6	5.61	66.6	4.75
May	71.4	4.79	73.0	3.08	73.6	4.28	73.6	4.18
June	77.6	6.24	79.3	4.58	79.4	4.64	79.6	3.85
July	78.6	5.43	81.4	4.50	81.0	5.00	81.7	4.47
August	77.8	4.46	80.3	4.00	80.6	4.05	81.4	5.05
September	73.0	2.83	75.9	2.48	75.4	2.52	76.6	2.46
October	65.0	1.65	63.7	1.85	64.6	2.02	65.4	1.78
November	53.4	3.09	54.7	2.88	56.1	3.10	55.1	3.00
December	50.5	5.29	46.8	4.70	48.6	4.84	47.8	5.02
Year	63.6	54.66	....	45.06	64.7	51.89	64.8	49.61

PHYSIOGRAPHY AND GEOLOGY.[a]

The surface of Sumter County is moderately hilly and broken. Such level tracts as do occur are found mainly in the central and northern parts of the county, in what is termed the "prairie section." The elevation above sea level ranges from 100 to 200 feet. The drainage is almost entirely toward the Tombigbee River on the east. Into this flow a great number of streams, having mainly an easterly or southerly direction. Of these the more important are the Sucarnochee River, Alamuchee Creek, Kinderbish Creek, and Noxubee River, which, with their many branches, completely drain the county.

Sumter County lies within that comprehensive physiographic region known as the "Coastal Plain." Four geological divisions found in this part of the plain give character to the soils. Beginning with the oldest or lowest, these are the Rotten limestone, the Sucarnochee clay, the Lafayette, and the Late Pleistocene.

The Rotten limestone is itself a subdivision of the Cretaceous, consisting of an impure limestone stratum, with the surface exposed in many places and underlying the whole of the remainder of the county. Its thickness seems to range from about 300 to 600 feet. It owes its origin to an offshore deposit laid down in a rapidly deepening sea during the latter part of Cretaceous time. Its texture is that of a loosely coherent limestone containing from 50 to 75 per cent of lime carbonate and 25 to 50 per cent of clay. This rock is exposed more or less throughout that part of the county lying north of the Sucarnochee River, and where exposed gives rise to two distinct soil types, namely, Houston black clay and Houston clay. Both are locally termed "prairie land," the former, however, being usually designated as "black prairie," and the latter as "lime hill prairie" land. The clay is lighter colored, the surface is more hilly, and the lime rock is possibly more often exposed in the latter type.

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[a] The matter pertaining to the geology of the area is based mainly on the Report on the Geology of the Coastal Plain of Alabama, 1894, by Eugene A. Smith.

There are some areas of the Rotten limestone which have the calcium carbonate and clay in such proportions as to make excellent cement, and there is a factory at Demopolis that manufactures cement out of the lime rock of that locality with success. Some of the Rotten limestone also has a considerable proportion of phosphate.

The Sucarnochee clays are exposed as a belt 4 or 5 miles wide extending through the county in a northwest-southeast direction, and mostly lying contiguous to the Sucarnochee River. They are a subdivision of the Lignitic of Lower Tertiary age. Two soil types are derived from this formation that are locally spoken of as "flat-woods post-oak" and "hilly post-oak." These appear in this report under the type names Lufkin clay and Lufkin clay loam, respectively.

The Lafayette, a sand and clay formation of Pleistocene age, is an interesting and important geological formation occurring chiefly in the southern part of the county, where it almost completely overlies the two formations already described, while throughout the remainder of the county it occurs as a capping here and there with considerable definiteness. It is locally spoken of as "sandy land," and, as may be readily inferred from its position, it modifies and gives character to most of the soils of the county.

Four distinct soil types are derived from the Lafayette, namely, the Orangeburg sand, Orangeburg fine sandy loam, Norfolk fine sandy loam, and Orangeburg clay, while indirectly it has modified the character of some of the other upland soils and contributed to the formation of the bottom lands.

The Late Pleistocene, or Recent, is the youngest formation in the county, forming the closing chapter in the geological history of this section. It probably includes all of the Norfolk sand, the Sassafras sandy loam, the Waverly loam, and Meadow, which in this county are all bottom-land types.

The drinking water of the area is obtained mainly from two sources—surface wells, from 10 to 50 feet in depth, and artesian wells, from 300 to 1,100 feet in depth. The water from wells sunk in the Lafayette formation is usually good, except as it may be contaminated from the surface. Some of the water from wells in the Sucarnochee clay is highly charged with mineral salts, among which magnesia in the form of Epsom salts is often prominent. Mineral water of like character was noted also in a well sunk in the clay overlying the Rotten limestone. These waters are often shipped to Birmingham, Meridian, and other points and used for medicinal purposes.

In the northern half of the county there are a number of artesian wells. Most of these are flowing wells, while from the rest the water is easily drawn by hand pumps. These artesian well borings are progressively deeper going from north to south, those in the vicinity of Warsaw, Ivy, and Gainesville being from 300 to 700 feet in depth, while at Epes and Livingston the depth is from 800 to 1,100 feet. The water from the artesian wells in the northern part of the county contains relatively small quantities of the mineral salts, while that of the wells at Epes and Livingston is very highly impregnated.

The presence of these flowing wells may some day prove very valuable in connection with the irrigation of truck or other special crops.

SOILS.

Twelve soil types were recognized in Sumter County, most of them being old-established types. The following table shows the actual and relative extent of each type:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Orangeburg fine sandy loam.	107,264	18.8	Sassafras sandy loam	33,408	5.8
Waverly loam	100,288	17.5	Houston black clay	26,648	4.9
Houston clay	59,048	10.2	Meadow	21,952	3.8
Lufkin clay loam	52,928	9.3	Norfolk sand	15,296	2.7
Lufkin clay	49,088	8.6	Orangeburg clay	12,800	2.2
Norfolk fine sandy loam	48,128	8.4	Total	571,456	....
Orangeburg sand	44,608	7.8			

ORANGEBURG SAND.

The Orangeburg sand consists of about 8 inches of dark-brown sand, underlain by a brown to red sand from 3 to 10 feet or more in depth. This, in turn, often grades into a red sandy clay, and the nearer the surface this occurs the better the type is for farming. The better phases often grade rapidly into the Orangeburg fine sandy loam type.

A large area of the Orangeburg sand occurs northwest of Gaston, where it is locally known as "sand-tuck" land, and another extensive area is found west of Belmont. It occurs in smaller areas in other parts of southern Sumter County.

The type forms a distinct upland, with a surface rather hilly and rolling. The stream valleys are deep, and, as a rule, the sides are steep. By reason of its elevation, open texture, and abundance of natural drainage ways, it is well drained, and rather inclined to suffer from drought during dry weather. The Orangeburg sand is derived from the deep sand of the Lafayette formation. There may be areas which have resulted from the sandy clay, where the clay particles have been removed by drainage waters.

The mineral constituent of the type is mainly quartz sand. The reddish color, due to the presence of red iron salts, is one of the characteristics separating this type from the Norfolk sand, which it resembles very much in texture.

The Orangeburg sand is naturally suited to the growing of truck crops, but at the present time the transportation facilities and market conditions do not favor any extended development of this industry. In the better phases of the type—those having an admixture of red clay in the subsoil, as is the case where this soil grades into the Orangeburg fine sandy loam—the staple crops, such as cotton and corn, are grown with moderate success. Peaches do well on some of these better areas. Cotton yields from one-fourth to one-half bale per acre, and corn from 5 to 15 bushels per acre.

The sandier phases of the type still remain in forest, supporting a scrubby growth of oak and often a fair stand of shortleaf pine. Little of the type is improved, and its value is low, ranging from 50 cents to $2 an acre.

The following table gives the results of mechanical analyses of typical samples of this soil:

Mechanical analyses of Orangeburg sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11317	1 mile SE. of Intercourse.	Gray loose sand, 0 to 10 inches.	1.1	14.1	21.5	37.9	12.5	9.0	3.7
11315	6 miles S. of Epes....	Brown sand, 0 to 10 inches.	1.7	20.0	17.1	27.8	7.1	18.9	7.3
11316	Subsoil of 11315......	Brown sand, 10 to 36 inches	2.7	20.3	17.0	28.0	8.0	15.9	7.9
11318	Subsoil of 11317......	Red sand, 10 to 36 inches..	1.6	39.3	19.2	20.9	6.2	1.7	10.9

ORANGEBURG FINE SANDY LOAM.

The Orangeburg fine sandy loam consists of 8 to 15 inches of gray sandy loam, underlain by a red sandy clay. The subsoil material varies in thickness from 5 to 50 feet or more, resting then either on a cross-bedded sand or sometimes on a heavy bluish clay. The red sandy clay is usually more or less cemented with iron and stands up readily in wells, curbing being unnecessary. In a few places some gravel is found, but except in rare instances not enough to influence the texture of the soil or to be of economic importance. The surface soil is invariably loose and easily tilled under almost all conditions of moisture.

The Orangeburg fine sandy loam occurs in broad areas throughout the southern third of the county, where the Lafayette covering is almost continuous, and in scattered areas throughout the remaining northern part of the county wherever there are remnants of the Lafayette sand and clay overlying the Rotten limestone. The surface of the type is rolling to hilly, with rather steep-sided stream valleys. The drainage is very good. The loose open soil favors the ready absorption of the rainfall, and the sandy clay substratum seems well adapted to storing and retaining it for the use of crops.

The Orangeburg fine sandy loam is derived from the sandy and clayey materials of the Lafayette formation. In Sumter County it is by far the most extensive of the Orangeburg series of soils, which series has been found in other soil surveys to be derived mainly from this geological formation.

Besides being adapted to the growing of the staple crops, the type is well suited to the truck crops and to peaches and strawberries. Trucking and fruit growing are now carried on at York and Livingston, where the transportation facilities are better. In central Georgia this is one of the types of soil preferred for peaches.

The crops commonly grown on the Orangeburg fine sandy loam in Sumter County are cotton and corn. The yield of cotton averages from one-fourth to three-fourths bale per acre, and of corn from 15 to 25 bushels. Recently more attention has been given to the growing of forage crops, and where care is taken to manure and fertilize the fields and to rotate the staples with leguminous crops these yields are considerably increased. It is said by those having wide experience with sandy soils in this section that even this, the best of the upland sandy types, requires abundant manure and fertilizer, systematically applied, to make farming profitable.

A considerable part of the Orangeburg fine sandy loam is cleared and farmed. The remainder supports a stand of shortleaf pine. The value of the land varies, according to the state of improvement, location, and value of standing timber, from about $5 to $12 an acre.

The following table gives the results of mechanical analyses of typical samples of this soil:

Mechanical analyses of Orangeburg fine sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11323	½ mile N. of Intercourse.	Gray sandy loam, 0 to 15 inches.	0.4	4.6	14.1	40.4	15.4	19.7	5.3
11321	5¼ miles NW. of Gainesville.	Gray sandy loam, 0 to 12 inches.	.9	6.2	8.8	22.5	13.3	39.7	8.3
11324	Subsoil of 11323	Red sandy clay, 15 to 36 inches.	.1	3.0	10.8	33.9	12.3	17.0	22.8
11322	Subsoil of 11321	Red sandy clay, 12 to 36 inches.	1.1	4.9	7.9	20.2	10.6	29.6	25.5

NORFOLK FINE SANDY LOAM.

The Norfolk fine sandy loam differs from the Orangeburg fine sandy loam in that it has a yellow sandy clay instead of a red sandy clay subsoil. The texture is the same throughout the profile, the soil consisting of 8 to 15 inches of gray sandy to fine sandy loam and the subsoil of a yellow sandy clay that extends to a depth of 36 inches or more.

The Norfolk fine sandy loam is not very distinct in this area, and it often grades rapidly into the Orangeburg fine sandy loam. Its total area is relatively small, although some considerable tracts are found in the southern, central, and northern parts of the county. Hixon, on the Alabama Great Southern Railway, is the center of the largest area.

As a rule, the surface of the Norfolk fine sandy loam seems to be rather flatter than that of the Orangeburg fine sandy loam. It is fairly well drained naturally, and only some of the more level areas require artificial draining, which is readily effected by means of open ditches.

The Norfolk fine sandy loam is probably derived mainly from the Lafayette formation. The soil is composed largely of quartz sand, and is not very retentive of moisture. The subsoil, containing varying quantities of clay and silt, maintains a much better moisture condition. The type has not the inherent productiveness of the types having the red sandy clay subsoil.

This type seems fairly well adapted to the growing of the staple crops. Cotton yields from one-fourth to one-half bale per acre and corn from 5 to 20 bushels. The forage crops yield fairly well. Small fruits, such as strawberries, and truck crops, like English peas, snap beans, cabbage, and sweet and Irish potatoes, are also successfully grown where liberal applications of fertilizer are used.

The following table gives the results of mechanical analyses of typical samples of this soil:

Mechanical analyses of Norfolk fine sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11311	3 miles SW. of Livingston.	Gray sandy loam, 0 to 15 inches.	1.2	3.0	4.9	21.3	19.3	42.2	7.7
11309	10 miles NW. of Gainesville.	Gray sandy loam, 0 to 15 inches.	1.1	2.2	4.0	26.8	20.9	31.2	13.5
11312	Subsoil of 11311	Yellow sandy clay, 15 to 36 inches.	1.1	2.5	4.0	18.5	15.1	42.7	15.9
11310	Subsoil of 11309	Fine sandy loam, 15 to 36 inches.	1.5	2.6	3.8	22.6	17.4	34.9	17.2

ORANGEBURG CLAY.

The Orangeburg clay consists of from 4 to 8 inches of reddish sandy loam, underlain by red clay, or, in some cases, slightly sandy clay. The soil in places may have quite a clayey texture, forming clods if plowed when too wet, or it may be a more typical fine sandy loam where it grades into the Orangeburg fine sandy loam, which occurs wherever the ordinarily shallow surface soil exceeds a certain depth.

The Orangeburg clay occurs only in relatively small areas. These are scattered throughout the county, occurring in conjunction with the sands and clays of the Lafayette, from which the soil is derived.

The surface is often rather flat, though hilly and rolling areas are also found. In the main the natural drainage is good, and artificial drainage, where necessary, may be readily effected by means of open ditches.

The Orangeburg clay is said to be the most productive soil of the series. It retains moisture well and is well adapted to the production of the staple crops. Small fruits and vegetables can also be grown successfully, but the staple crops—cotton, corn, and forage—together with stock raising, are probably the best lines of agriculture to be practiced.

Under the ordinary methods of culture, where only a moderate amount of fertilizer is applied, cotton yields on an average from one-half to three-fourths bale per acre, and corn from 15 to 30 bushels. The yields of the forage crops are very good.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Orangeburg clay.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11329	3 miles NE. of Ramsey.	Brown sandy loam, 0 to 6 inches.	2.0	13.9	9.1	16.5	11.2	27.3	20.1
11327	1¼ miles of Sumterville.	Red loam, 0 to 6 inches...	.4	1.1	1.1	12.6	26.0	22.2	36.2
11330	Subsoil of 11329......	Red sandy clay, 6 to 36 inches.	.7	11.7	9.6	15.9	11.8	24.9	25.3
11328	Subsoil of 11327......	Red clay, 6 to 36 inches...	.1	.5	.5	12.1	22.4	17.8	47.0

HOUSTON BLACK CLAY.

The Houston black clay, or "black prairie land," as it is locally called, consists of from 4 to 8 inches of a brown to black clay loam, underlain by a brown to gray or grayish-white clay 3 to 10 or more feet in depth. This material rests directly on Rotten limestone. The greater part of the soil of this type is black, the brown color occurring only in the elevated and better drained areas. The subsoil of these areas is also a lighter gray, and in places the limestone is exposed.

The Houston black clay occurs in considerable areas in the central and northern parts of the county, in what is known as the "black prairie," or canebrake belt. It is much interrupted by areas of Houston clay, as well as by areas of the more sandy types.

The surface of the Houston black clay is comparatively flat, but, as a rule, the soil is well drained naturally, and only a few instances were noticed where artificial drainage was required.

The Houston black clay owes its origin to the weathering of the Rotten limestone—a very impure limestone, of a loose structure, containing from 25 to 50 per cent of clay. Over some areas the limestone has a covering of gray jointed clay, probably deposited while the rock was under the sea. Where this clay is found it has probably entered into the formation of the Houston black clay, but by far the greater part of the type has been formed from the residue of the limestone left through the solution of the calcium carbonate in rainwater and modified by other agencies of weathering.

In some areas of the type there are many shells from 1 to 3 inches in diameter. There are also in many places concretionary nodules, from one-fourth to 1 inch in diameter, said to be high in lime and phosphate, but probably a more prominent feature throughout the soil and subsoil of all the type is the mottling of the clay with small beadlike bodies having the appearance and texture of the Rotten limestone. The character and abundance of these shells and nodules have an important influence on the texture of this clay land, as they make it more friable. The breaking down of these materials may also have some effect on the productiveness of the type. It is the experience of the farmers that little if any benefit is derived from the addition of mineral fertilizer to this land, but where stable manure and other vegetable manures have been used and leguminous crops grown its productiveness is decidedly increased. Crops have been grown and good yields obtained continuously on many farms on the Houston black clay for many years without the use of fertilizers, thus attesting the great natural fertility of the type.

The Houston black clay has a tendency to bake and become difficult to plow, while if plowed when too wet large clods are formed that do not easily disintegrate. Failure to apply vegetable manure and to grow leguminous crops to loosen up the soil increases this tendency. Experience with areas which have been neglected in these ways has shown that, as a rule, the surest and quickest way of putting the soil in good tilth again is to plow the land in the fall, thereafter harrowing or stirring it with a cultivator only when the moisture conditions are right. Even if the soil be too dry at the fall plowing the winter rains are likely to assist much in the melowing process.

The Houston black clay seems especially well adapted to the growing of forage crops, and is therefore very well suited to the live-stock industry, which is being considerably extended. The staple crops—cotton and corn—also produce well on this type. These crops have been grown continuously for over half a century in some parts of the county with good success. The yields average from three-fourths to over 1 bale of cotton, and from 20 to 50 bushels of corn per acre. In recent years considerably more attention has been given to the growing of grasses and forage crops than formerly. Johnson grass, alfalfa, and sweet clover (*Melilotus alba*) are prominent varieties. The latter two yield from 3 to 6 tons per acre, with two or three cuttings a season. Many farmers object to seeding their lands to Johnson grass, because it spreads rapidly and is very difficult to eradicate when once it gains a foothold. It is very troublesome in the cotton and corn fields.

Practically all of the Houston black clay is cleared and under some form of cultivation. Good farm houses and other substantial improvements are often seen on the type. Its value ranges from $5 to $15 an acre.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Houston black clay.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11291	1 mile W. of Geiger.	Black loam, 0 to 8 inches.	2.3	3.2	2.9	9.6	11.4	55.8	14.9
11295	6 miles S. of Gainesville.	Black clay loam, 0 to 6 inches.	.5	1.7	1.4	4.9	5.1	57.9	28.5
11293	2 miles S. of Gainesville.	Black clay, 0 to 6 inches.	1.2	1.6	1.4	5.1	5.3	42.2	43.2
11296	Subsoil of 11295	Dark clay, 6 to 36 inches.	1.1	2.0	1.9	6.9	5.7	54.6	28.0
11292	Subsoil of 11291	Dark to gray clay, 8 to 36 inches.	3.2	3.9	2.3	6.0	7.0	47.7	29.9
11294	Subsoil of 11293	Black clay, 6 to 36 inches.	.6	1.8	1.6	5.4	4.3	49.0	37.6

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 11291, 4 per cent; No. 11292, 18.3 per cent; No. 11295, 1 per cent; and No. 11296, 1.5 per cent.

HOUSTON CLAY.

The Houston clay consists of from 4 to 8 inches of brown to almost white clay loam, underlain by a brown to gray or grayish-white clay, which often rests on the lime rock at a depth of 18 to 36 inches. The type differs from the Houston black clay, mainly in that it is lighter colored, the surface is more hilly, and the limestone is more often exposed. It is often spoken of locally as the "lime-hill prairie," in distinction from the more level prairie occupied by the Houston black clay.

Important developments of the Houston clay occur east and northeast of Livingston, west of Gainesville, and around Epes and Sumterville.

The type, being rather hilly, is naturally well drained, and there is seldom any need of artificial drainage. Like the soil just described, it is derived from the weathering of the Rotten limestone, and the difference in the two types is due to dissimilarity in the surface and drainage conditions and the consequent condition as regards organic matter. The surface of the Houston clay not being favorable to the accumulation of water, the growth of vegetation has been less, and the organic matter resulting from its decay has been insufficient to blacken the soil. Then, too, the system of cropping, with clean cultivation, leaving the soil unprotected from year to year, has favored washing of the fields, exposed the underlying rock, and further depleted the supply of vegetable mold.

In mineral constituents the Houston clay is doubtless identical with the Houston black clay, and the statements made in the description of the latter type apply here with equal force. Mica fragments, however, seemed more frequent in the subsoil of this type than in the Houston black clay.

Except in very dry seasons the staple crops, cotton, corn, and forage crops, are grown quite successfully on this type. The nearness to the surface of the underlying lime rock is the principal cause of droughtiness in many areas, while the more thorough surface drainage is an important factor in the lessened moisture supply throughout the type. With a fair amount of rainfall, however, the type yields well, and the indications are that this is naturally nearly as productive a type of soil as the Houston black clay. Where there is a fair depth of soil and subsoil the yield of cotton is considerably better than on the black prairie areas, the lower humus content of the Houston clay being an advantage in the production of this crop, as a less bushy growth of plant and a more abundant fruiting are induced, even in wet seasons.

As a rule, however, the type is not well adapted to such clean culture crops as cotton, corn, etc., for the reason that washing and gullying are apt to be severe. As a result, exposures of the underlying rock are being extended, the depth of the soil covering reduced, and the land as a whole is becoming more subject to drought. Some system of cropping in which the land is plowed only at relatively long intervals is needed on this type, and the growing of forage crops, coupled with stock raising, is probably the best line of agriculture to be followed where this soil is the predominating type. Sweet clover seems to have a root system that adapts itself very well to shallow soils, growing very well even on the almost bare lime rock. The clover may be cut for hay, but where the rock is much exposed it is better to use the land for pasture. That part of the type having considerable depth of soil and subsoil is much improved by the growth of leguminous crops, as shown by the increased yield of succeeding crops of cotton, corn, and grasses.

The proportion of the Houston clay now under cultivation is considerably less than in the case of the Houston black clay, and the average value is lower, prices ranging from $2 to $8 an acre.

The table on the following page gives the results of mechanical analyses of typical samples of the Houston clay.

Mechanical analyses of Houston clay.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11299	1 mile S. of Epes	Brown loam, 0 to 6 inches.	2.7	2.3	2.4	10.2	8.1	57.0	17.4
11301	1 mile NE. of Livingston.	Brown loam, 0 to 6 inches.	.6	1.1	1.2	20.0	20.3	34.0	22.4
11297	2 miles NE. of Sumterville.	Brown clay loam, 0 to 6 inches.	1.6	2.5	1.8	8.3	9.0	42.1	34.3
11302	Subsoil of 11301	Loam, 6 to 36 inches	.8	1.8	1.6	23.2	20.0	31.6	21.4
11300	Subsoil of 11299	Yellow silty clay, 6 to 36 inches.	.7	1.5	1.3	6.6	5.2	58.5	25.8
11298	Subsoil of 11297	Gray clay, 6 to 24 inches.	.8	1.6	1.1	8.2	10.8	32.6	45.1

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 11297, 24 per cent; No. 11298, 76 per cent; No. 11299, 16 per cent; No. 11300, 8.1 per cent; No. 11301, 4.8 per cent; and No. 11302, 53.1 per cent.

LUFKIN CLAY.

The Lufkin clay consists of from 3 to 6 inches of dark-gray, sticky clay loam or clay, underlain to a depth of 3 feet or more with an exceedingly sticky mottled red and gray clay subsoil.

The type includes chiefly lands locally known as "flat-woods post oak," and occurs as a broken band 4 or 5 miles wide extending through the county in a northwest-southeast direction. The surface is very flat and poorly drained.

The Lufkin clay is derived from the Sucarnochee formation, a subdivision of the Lignitic, which itself is a division of the Lower Tertiary. It is a stiff, impervious clay, very hard to drain or cultivate. Under certain conditions it can be plowed fairly well, but the range of moisture content with which cultivation can be carried on satisfactorily is so narrow that utilization of the type from year to year is very uncertain. It could doubtless be considerably improved in respect of this refractory condition by the application of stable manure or the plowing under of green crops, which would have the effect of making the clay less compact and thus more easily drained. The application of crushed limestone would also improve the mechanical condition of the type, at the same time adding a mineral in which it seems to be deficient.

Very little of the Lufkin clay is as yet under cultivation. Much of it is still covered with the native forest growth, consisting of shortleaf pine and small oaks, the latter of a size suitable for fence posts.

Cotton and corn are grown on this type, and give good yields in favorable seasons. Cotton yields from one-half to over 1 bale per acre, and corn from 10 to 30 bushels, and this, too, under quite ordinary cultural methods. With better methods, including manuring and liming, these yields could be considerably increased. Under the present conditions of agriculture, however, with large areas of other and more easily tilled lands, no very extensive improvement of this type can be expected in the near future, though as soon as the population becomes greater and lands generally come into greater demand this clay will be brought under cultivation. For the present the type serves best as a stock range. The cleared areas should be kept as much as possible in some of the grass crops, Johnson grass and Japan clover having been found valuable. This will eliminate the necessity for plowing the land except at long intervals. The grass can be pastured or cut for hay, according to circumstances. The forested area usually contains an undergrowth of grass and shrubbery suited to stock. Where the merchantable timber has been cut, the value of the Lufkin clay ranges from 25 cents to $1 an acre.

The following table gives the results of mechanical analyses of typical samples of this soil:

Mechanical analyses of Lufkin clay.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11345	5 miles W. of Sumterville.	Gray clay loam, 0 to 6 inches.	0.8	5.7	4.2	14.7	7.6	43.1	23.9
11347	7 miles W. of Sumterville.	Dark-gray clay, 0 to 6 inches.	.1	1.4	.9	3.0	3.8	62.5	28.6
11349	5 miles NW. of Coatopa.	Dark-gray clay, 0 to 4 inches.	.8	4.3	3.1	8.7	4.9	38.4	39.9
11348	Subsoil of 11347	Gray clay, 6 to 36 inches	.1	.9	.5	1.7	2.6	52.8	41.4
11346	Subsoil of 11345	Gray clay, 6 to 36 inches	.8	3.0	2.4	7.1	4.3	32.3	50.0
11350	Subsoil of 11349	Gray clay, 4 to 36 inches	.3	2.5	2.1	4.5	3.3	29.7	57.6

LUFKIN CLAY LOAM.

The Lufkin clay loam consists of from 4 to 8 inches of gray loam or clay loam, underlain by a sticky, mottled gray clay. It is locally included with the preceding type, as "post-oak land," but differs from it in being rather more hilly, slightly lighter textured, and much easier to cultivate.

The type occurs in broken bands lying between the Lufkin clay and some of the sandy types. It also occurs to a considerable extent throughout the prairie section of the county, adjacent to the sandy types, where much of it is under cultivation.

Owing to the more rolling surface of this type it is naturally much better drained than the preceding type, while the more open texture of the soil makes artificial drainage by open ditches more effective.

The Lufkin clay loam owes its origin apparently to a mixture of silt and sand of the Lafayette formation with those of the Sucarnochee clay formation, and its mineral constituents are very similar to those of the Lufkin clay.

The range of moisture conditions within which this soil admits of tillage is considerably wider than that of the preceding type, and as a consequence much of it is cultivated every year; but it will clod if plowed when too wet, while if very dry the subsoil, which the plow must penetrate, makes plowing extremely difficult, if not impracticable. A deficiency in lime is also ascribed to Lufkin clay loam, as in the case of the preceding type. Hence the addition of lime and vegetable manure in the same manner as suggested for Lufkin clay would doubtless be very beneficial to this type also.

The type is very well adapted to the staple crops, and in the lighter phases to strawberries and some truck crops. The yields of the staples are good. Cotton yields from one-half to nearly 1 bale per acre, and corn from 15 to 40 bushels. Grasses, leguminous, and other forage crops yield well, and if used systematically in rotation with the staple crops the yields could be made much better than at present.

Some good and fairly well improved farms are to be found on this soil. Its average value is considerably above that of the preceding type, ranging from $2 to $6 an acre. The portion still in forest supports a good stand of shortleaf pine and small, scrubby oak.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Lufkin clay loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11841	1 mile E. of Ramsey.	Yellow loam, 0 to 10 inches.	1.4	4.2	3.3	23.0	12.1	36.9	18.8
11839	1 mile S. of Geiger ..	Loam, 0 to 5 inches	3.1	5.9	3.3	11.6	7.8	46.5	21.8
11843	4 miles W. of Bellamy.	Silty clay loam, 0 to 6 inches.	1.5	3.3	2.8	4.7	3.4	50.4	33.8
11842	Subsoil of 11841	Mottled-red clay, 10 to 36 inches	.5	2.6	2.2	14.4	6.3	33.7	40.5
11840	Subsoil of 11839	Gray clay, 5 to 36 inches .	1.5	2.8	1.7	6.0	5.2	40.8	41.9
11844	Subsoil of 11843	Gray clay, 6 to 36 inches .	.5	2.6	1.9	3.0	3.6	36.5	51.9

NORFOLK SAND.

The Norfolk sand consists of from 4 to 8 inches of loose gray to dark-brown sand, underlain by a loose brown to whitish sand 3 feet or more in depth. The soil and subsoil are composed mainly of quartz sand. The first few inches are stained somewhat by organic matter, while the brown color sometimes seen in the subsoil is probably due to the presence of iron salts.

This type of soil occurs as deep sandy bottoms along the Tombigbee and Sucarnochee rivers, and other streams of this character. Sometimes it is in the form of elevated ridges not unlike second bottom, and again it is found as broad, flat, low-lying areas. Even in the latter situation, owing to its open texture, it is usually well drained, and for this reason is apt to be droughty in dry weather.

The Norfolk sand is derived from the Pleistocene sands of comparatively recent origin, being due in part to the action of streams when these flowed at a higher level than at present. During excessive floods some parts of the type are still being built up by the addition of sediments. This is especially the case in river necks where the flood water flows rapidly and directly across to some lower bend in the river.

The type is naturally adapted to truck growing, but requires the application of large quantities of vegetable and mineral manures in order to make it productive. Since the market for truck crops is as yet comparatively undeveloped in this section, not much of this soil is under cultivation. When used at all it is generally as part of a field composed mainly of some of the more productive types.

The following table gives the results of mechanical analyses of typical samples of the Norfolk sand:

Mechanical analyses of Norfolk sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11303	8¼ miles NW. of Gainesville.	Gray sand, 0 to 8 inches...	0.4	4.4	14.3	41.0	12.9	22.7	4.2
11305	3 miles SE. of Epes..	Brown sand, 0 to 10 inches.	.3	5.9	17.8	43.9	10.8	5.8	15.5
11304	Subsoil of 11303......	Gray sand, 8 to 36 inches.	.4	4.2	13.5	38.2	11.1	25.6	6.5
11306	Subsoil of 11305......	Yellow sand, 10 to 36 inches.	.2	5.3	17.5	46.2	12.7	6.1	12.0

WARSAW SANDY LOAM.

The Sassafras sandy loam consists of from 8 to 15 inches of fine sandy loam, underlain to a depth of 36 inches or more with a fine sandy clay subsoil brown to yellow in color. The color of the soil is usually brown or light brown, with variations toward a dark gray in the lower depressions. The texture in the latter areas may also be rather silty, the lighter texture being found on the slightly higher elevations.

The type occurs mainly as second bottom terraces along the Tombigbee River and some of its tributary streams, in areas varying in width from one-fourth to 1 mile and in length from 1 to 5 miles. These areas are usually bounded on one side by the upland escarpment and on the other by the lower lying bottom.

The surface is usually flat, but by reason of the texture of its soil and subsoil and its elevated position the type is quite well drained naturally. It is overflowed only in cases of unusually high water.

The Sassafras sandy loam is derived from materials of Pleistocene age. It appears to have been laid down in the stream valleys of Cretaceous age with much the same structure as now found.

The Sassafras sandy loam is naturally quite productive and most of it is cleared and cultivated. It is well adapted to the growing of staple crops and to many of the truck crops. On the more elevated areas small fruits and peaches do very well. Cotton yields from one-half to three-fourths bale per acre, and corn from 10 to 20 bushels. The grasses, clovers, leguminous plants, and other forage crops produce very well.

The following table gives the results of mechanical analyses of typical samples of this soil:

Mechanical analyses of Sassafras sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11333	2¼ miles NW. of Gainesville.	Gray sandy loam, 0 to 12 inches.	0.1	1.8	3.7	35.3	19.1	33.4	7.2
11337	4 miles SW. of Coatopa.	Brown sandy loam, 0 to 15 inches.	1.2	2.7	3.7	25.3	26.9	27.5	12.5
11335	2¼ miles SW. of Fairoaks.	Brown sandy loam, 0 to 10 inches.	.3	.7	2.4	52.5	17.4	13.9	12.7
11334	Subsoil of 11333	Sandy clay loam, 12 to 36 inches.	.2	.9	2.6	22.9	17.1	33.2	22.8
11338	Subsoil of 11337	Stiff clay, 15 to 36 inches.	.0	1.4	3.2	19.2	26.7	19.5	30.0
11336	Subsoil of 11335	Red sandy clay, 10 to 36 inches.	.1	.5	.8	23.0	13.0	23.5	39.3

WAVERLY LOAM.

The Waverly loam consists of from 8 to 10 inches of dark-brown silty or fine sandy loam, underlain by a brown clay or heavy silty loam. As a rule the texture follows pretty closely the above description, but it may vary, on the one hand or the other, toward a rather heavy clay or toward a sandy loam, in which latter case it may grade rapidly into the Sassafras sandy loam.

The type occurs as first bottom land along the rivers and creeks of the area. The surface is quite flat, as a rule, though occasionally there are broad elevations having a slightly rolling surface, and here the soil may contain a little more sand than in typical areas.

Owing to its rather level surface the Waverly loam frequently needs drainage. This may usually be effected by means of open ditches, which can be led into some natural channel close at hand. As a rule, the type is readily drained when the streams are at their normal stage. It lies from 5 to 20 feet above the normal level of the streams, and some of it is subject to overflow nearly every year. The remainder is overflowed only at rare intervals.

The Waverly loam owes its origin mainly to deposition of silt and clay from the flood waters of the streams, and in this way it is being built up from time to time. Each overflow adds more fertility to a type already quite rich, judging from the crop yields, in the humus and mineral salts needful to plant growth.

A large proportion of the type is cleared and under some form of cultivation. The lower lying areas are often covered with forests, which consists mainly of deciduous trees, such as gum, sycamore, water oak, beech, and willow. The rank growth of switch cane usually found in these forested portions of the type affords excellent wild pasture for live stock in winter as well as in summer.

The staple crops, cotton and corn, as well as the forage crops, are well suited to this type. Cotton yields from three-fourths to 1 bale or more per acre, and corn from 20 to 40 bushels. Cotton and corn are planted after the greatest danger from floods has passed. The high water usually occurs in February and March, but in some years floods come as late as June, and then practically all planted crops are destroyed. Many of the grasses are not injured by the floods, and the type is adapted to such perennial crops.

The table on the following page gives the results of mechanical analyses of the soil and subsoil of this type.

Mechanical analyses of Waverly loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11287	1 mile W. of Gainesville.	Loam, 0 to 10 inches	0.3	1.4	2.0	17.2	20.8	41.3	17.0
11285	3¼ miles SE. of Epes.	Loam, 0 to 8 inches	.1	.3	1.3	24.3	22.2	30.8	20.8
11288	Subsoil of 11287	Gray silty clay, 10 to 36 inches.	.4	2.7	1.6	15.8	20.9	31.4	27.1
11286	Subsoil of 11285	Clay to sandy loam, 8 to 36 inches.	.1	2.8	8.1	14.7	9.7	28.7	35.2

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 11286, 13 per cent; No. 11285, 18 per cent. The locality where these samples were taken receives the wash from the adjacent lime-hill prairie lands, which probably accounts for the greater lime content found here than in other parts of this soil type.

MEADOW.

The Meadow, like the preceding type, is first bottom land, but as it lies at less elevation above the streams and is thus more subject to overflow, it was deemed advisable to recognize it as a separate type. Much of it is often locally called "swamp." It consists of from 4 to 8 inches of a dark silty or fine sandy loam or clay loam, underlain to a depth of 36 inches or more with a brown to mottled-gray clay. As a rule, it is somewhat heavier in texture than the Waverly loam, the "black waxy clay" phase being more prominent in the Meadow than in the other type.

This soil is not so extensive as the Waverly loam, being limited to some of the lower depressions of the first bottom of the Tombigbee River. The largest area is found north of Black Bluff landing.

The surface being low and flat, the type is not naturally well drained. Then, too, it is at present heavily forested, which retards surface drainage. By the aid of open ditches, however, the type can be readily drained when the Tombigbee River is not above its normal stage. This soil is the first to be overflowed during any general rise of the flood waters, and scarcely a season goes by but these bottoms are more or less flooded, while by reason of the inadequate natural drainage even heavy rainfalls flood the surface.

Owing to its mode of origin, the building up of the low bottoms with fluvial sediments, the type is well supplied with organic and mineral elements of fertility, and these are being added to from season to season.

Scarcely any of this type is cultivated, nearly all being in forest. This consists of water oak, gum, sycamore, beech, willow, and originally cypress, but the latter has nearly all been removed by lumbermen.

The type, as far as tried, produces very good crops of cotton, corn, and the grasses and other forage crops, but because of the danger from overflow very little use is made of it. At present it is used mainly as wild pasture for cattle and hogs, and for this purpose it serves very well. The tall switch cane affords excellent browsing during winter. The live stock must be carefully watched, however, for considerable loss may result by drowning if sudden floods occur.

AGRICULTURAL METHODS.

The cultural methods followed for cotton are about the same as those followed elsewhere in the Gulf States. The land is given a shallow plowing either in the fall or spring, the soil being thrown into ridges 3 or 4 feet apart, following contours on the hillsides. The seed is planted from the middle of March to the middle of April, being dropped along the tops of the ridges, usually with a horsepower cotton planter, which opens up the furrow, drops the seed, and covers it, all in the same operation. Sometimes the furrow is opened up with a small shovel plow, and the seed dropped by hand and covered with a plank scraper.

Deeper plowing of the cotton fields, say from 6 to 8 inches instead of the usual 3 or 4 inches, would be a great improvement over the present practice. This would insure a better covering of the surface litter left from preceding crops, placing it where it would more readily decay and be converted into plant food. The mechanical condition of the soil would also be improved, a greater proportion of the rain water would be absorbed, and with less surface water to run off washing and gullying would be reduced. All these factors would tend to enable the preparation of a better seed bed.

A common method of cultivating cotton and corn is to run a shovel plow or "diamond scooter" between the rows, throwing the soil against the plants. Instead of this a better practice would be to give these crops level, shallow cultivation, stirring the soil 2 or 3 inches with a modern harrow-toothed two-horse cultivator. By the present method the crops are often injured by too severe pruning of the roots, while by the method advised, which gives a more complete cultivation of the surface, the roots are not injured, the weeds are just as effectively destroyed, the soil moisture is more surely conserved, and the soil is left in a fine porous structure favoring the absorption of a larger part of the rainfall.

While the student of agriculture finds some progress in the methods of cultivating cotton, he can not but be struck by its insignificance as compared with changes that have taken place in the methods of handling the product after it has been harvested. The horse-power gin and the old buzzard-wing press have largely been displaced by improved machinery operated by steam. The cotton is unloaded from the wagon by suction tubes, and after being ginned the lint and seed are separated and carried by air pressure to the storage bin and the press. Hand labor has been almost entirely eliminated, while the cotton tests a grade or so higher than under the crude earlier methods, owing to the removal of a greater quantity of the dirt and dust formerly left in the bale. It seems strange that the growers have not more generally profited by this object lesson and made those changes in the culture of the crop which have been so often recommended and are so palpably needed.

The planter still depends largely on commercial fertilizer to produce his crop of cotton or corn. From $15,000 to $20,000 is expended annually for this fertilizer in Sumter County. Cowpeas, oats, sweet and Japan clover, Johnson grass, Bermuda grass, and other forage crops are grown, but usually no systematic rotation calculated to increase the productiveness of the soil is followed. If the clean-culture summer crops, like cotton and corn, were followed in the fall by seeding some of the forage crops, needed additional food for the work stock would be provided, the productivity of the land not only conserved but increased, and all at a considerable saving in the outlay for fertilizers. In short, deep plowing, the growing of more forage crops, the practice of fixed rotations, and the raising of more live stock are the important factors in a well-balanced agriculture suited to the region. Cotton must remain, for the present at least, the chief money crop, and the changes recommended above can be made in such a way as not to decrease, but rather to increase, its production and the profit derived by the planter from its cultivation.

AGRICULTURAL CONDITIONS.

Sumter County is sparsely populated, having about 36 persons to the square mile, of whom only about one-fifth are white. In the southern part of the county, where the lands consist mainly of the sandy types of soil, the white and colored races are about evenly divided, while in the northern part, or "prairie section," the colored population largely outnumbers the white. The planters are, on the whole, in quite a prosperous condition.

According to the Twelfth Census there were 5,140 farms in Sumter County, but this does not represent the individual holdings, as the census classed each tract farmed by a tenant as a "farm." As the tenant system largely prevails, the number of farms, as ordinarily understood, must be very much below the figures quoted. Fifteen per cent of the farms enumerated are operated by the owners, all the others, with the exception of about 2 per cent operated by part owners or managers, being farmed under some system of tenantry. Aside from the large proportion of farms operated by tenants, a striking feature of the condition of the county as to tenure of farm lands is the relatively large number of cash tenants, who, according to the authority quoted, operate 67.9 per cent of the total number of farms.

According to the last census the average size of farms is 79.1 acres, but this is also misleading, because of the classification of each tenancy as a farm. On the basis of ownership there are several farms containing from 500 to 2,000 acres, and the greater number are probably from 200 to 400 acres in extent.

The labor is largely colored. It is chiefly unskilled, and in some sections, owing to the higher wages offered by the lumbering interests, difficult to secure. The conditions, on the whole, are such as to discourage investments or enterprises that must depend for their success chiefly on hand labor.

The value of the annual products not fed to live stock is, according to the Twelfth Census, $1,947,694, of which total cotton, the most important product, is credited with about three-fourths. Cotton is grown pretty generally throughout the county, large shipments being made from several points on the Tombigbee River and from the railway towns of Cuba, York, Coatopa, Livingston, and Epes. Corn ranks next in importance, having a value of about $30,000. Oats, Irish potatoes, sweet potatoes, miscellaneous vegetables, sugar cane, sorghum cane, peas, and peanuts represent a value of about $300,000, according to the same authority.

During the last decade there has been a considerable increase in the production of truck crops, especially at Cuba, and to some extent around York and Livingston. The shipments of English peas, snap beans, cabbages, and sweet and Irish potatoes from Cuba alone have an estimated value of from $25,000 to $50,000 annually. This industry was started by local enterprise and is being extended. The small-fruit interests at present are centered mostly at York and Livingston. In good seasons from $10,000 to $15,000 worth of berries are shipped. As a rule fairly good profits are reported by the strawberry and truck growers, and there is room for a considerable extension of these industries.

The annual value of forest products, lumber, cross-ties, etc., is given by the census report as $16,589, which is probably less than their value in the last few years. There are two large sawmills in the county, located at Sumter and Bellamy, which are equipped with improved high-grade machinery, and whose output is very large. In addition there are several smaller ones of the portable type in operation in different parts of the county. Pine and oak lumber is the chief output of all these mills. There is still some cypress in the area, but the supply is almost exhausted.

In connection with the foregoing enumeration of the principal crops it may be well briefly to review the soils and their crop adaptations. This feature is, of course, brought out in the consideration of the soil types earlier in the report, but a short synopsis here is deemed advisable because of the importance of this subject in a report of this kind.

The Orangeburg sand is naturally a truck soil, but in this county it is rather too distant from railway service to be used for trucking. Some of the phases having a heavier subsoil are good for peaches and pears, but the same objection to its use for these products applies as in the case of truck. In favorable seasons fair yields of the staple crops are secured.

The Orangeburg fine sandy loam occurs extensively throughout the county, and is quite productive of the staple crops, cotton and corn, as well as truck and fruit crops. It is mainly on a similar type of soil that the great peach industry of central Georgia has been developed.

The Norfolk fine sandy loam is not naturally quite so productive as the Orangeburg fine sandy loam, but by manuring and proper crop rotation it can be made to produce large yields of the staple crops as well as of fruits and truck crops. In eastern North Carolina the Norfolk fine sandy loam is noted for its adaptability to the production of a thin yellow leaf tobacco.

The Orangeburg clay occurs to only a limited extent in the county, but it is naturally productive and well adapted to the staple crops, cotton and corn, as well as to various kinds of forage crops suited to the live-stock industry.

The Houston black clay, locally known as " black prairie," is naturally the most productive of the upland soils. Cotton and corn are grown almost continuously without fertilizer. Forage crops produce exceptionally well, thus materially favoring an extension of the live-stock industry.

The Houston clay is similar in origin to the preceding type, but it is lighter colored, the surface is more hilly, and the type somewhat less productive, though cotton, corn, and forage crops produce very well, and the type is also well suited to the live-stock industry.

The Lufkin clay loam possesses fair natural fertility and produces moderately good crops of the staples grown. It is, however, very sticky when wet and very hard and difficult to handle when dry, and is not regarded with so much favor as the two preceding types.

The Lufkin clay is considerably heavier in texture than the preceding type, and is therefore even more difficult to till. At present very little is cultivated. Where it has been put in fair condition, with favorable seasons, it gives good yields of cotton and corn, but it is naturally better adapted for permanent pasture land. A valuable crop for grazing purposes is Japan clover, or Lespideza, which is said to do well on this soil.

The eight types above considered are all upland soils. The four following are bottom-land types:

The Norfolk sand occurs as first and second bottom lands, and is adapted to the culture of truck crops, watermelons, etc. It is not very productive of the staple crops, though these are grown to a limited extent on the better areas.

The Sassafras sandy loam occurs mainly as second bottom land, and is quite productive of the staple crops, the yields being nearly as good as on the Orangeburg fine sandy loam. Truck crops, like sweet potatoes, melons, etc., and also peaches, produce very well. Most of this type is under cultivation.

The Waverly loam occurs as first bottom land, and is the most productive of the bottom-land types. Much of the type is used in the growing of cotton, corn, and forage crops, for which it is very well adapted.

The Meadow consists of lower lying areas along the streams that are still in a more or less swampy condition. It is not used for cultivated crops, and is covered for the most part with forest and an undergrowth of cane, which furnishes considerable grazing.

The transportation facilities for much of the county are as yet rather inadequate. The southern part of the county is reached by the Alabama Great Southern Railway and the Southern Railway, the former affording connection with a through-line service from New Orleans to New York and other points north. The northern portion of the county has no nearer railways than those just mentioned.

The Tombigbee River is navigable for large boats about three or four months in the year, from January to April. This service, however, is quite uncertain and unsatisfactory at present. The construction of locks is under consideration, with a view to making the river navigable the year round.

The wagon roads of the county, both public and private, are rather poor, but a definite movement is being made this season (1904) to improve them. A bond issue of $120,000 has been voted for road improvement. A careful study of the available material near at hand suitable for road building has been made by those having the matter in charge, and improved road machinery, consisting of reversible road machines, heavy horsepower rollers, etc., has been purchased by the county.

From the foregoing it may readily be inferred that the market conditions for the greater part of the county are at present not very good. The local market for agricultural products is small. Cuba, York, Epes, Gainesville, and Livingston, with populations ranging from 400 to 900, are the principal towns in the county.

With the promised improvement of the wagon roads and the building of the new railway line projected through the north end of the county, better markets, both local and distant, will open up. Until the transportation facilities are improved, however, there will be little opportunity to specialize the crops recommended for the lighter types of soil, and the principal products must continue to be cotton, corn, and live stock, all of which can be handled without especially rapid transit facilities. If any extended development of the fruit or trucking industry is to take place, except immediately along the present railroads, canning, pickling, or distilling factories will have to be built in the locality where the products are grown.

SOIL SURVEY OF THE JACKSON AREA, MISSISSIPPI.

By J. O. MARTIN and O. L. AYRS.

LOCATION AND BOUNDARIES OF THE AREA.

The area covered by the present survey includes parts of Hinds, Rankin, Simpson, and Copiah counties, or the southern two-thirds of the Jackson quadrangle, United States Geological Survey. The area is a parallelogram, approximately 30 miles wide from east to west and 24 miles from north to south, and comprises 737 square miles. The

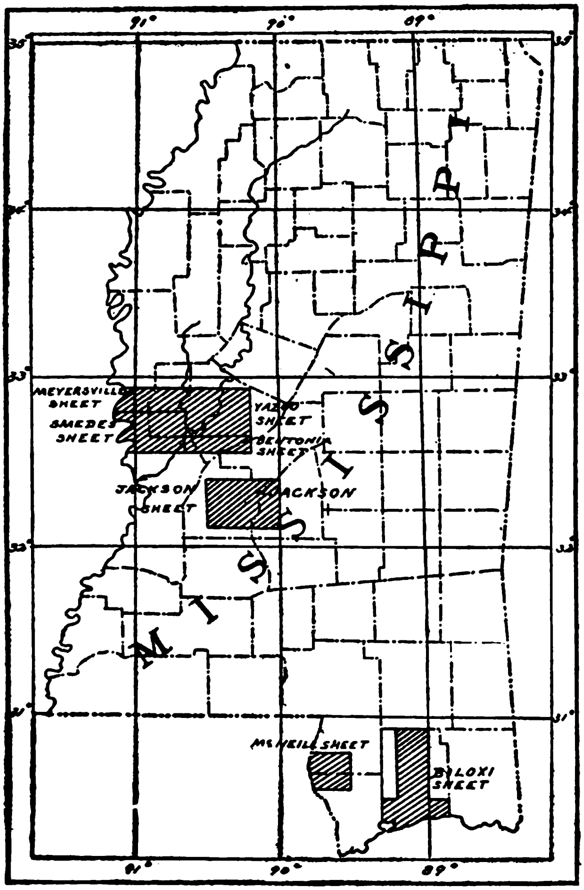

FIG. 13.—Sketch map showing location of the Jackson area, Mississippi.

Pearl River crosses the area from north to south, dividing it into two unequal parts, of which the western is the larger.

Jackson, the capital of Mississippi, lies about 3 miles from the northern boundary. It has a population of 7,816, and is the largest town in the area. The other principal towns are Raymond, Terry, Clinton, and Florence, each of which has less than 500 inhabitants.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Although white settlers had lived within the Jackson area for some time prior to 1820, it was not until after that year that permanent settlement and development really began. In 1821 the site for the capital was selected, and settlers came in from the older communities along the Mississippi River, and also from Kentucky, Tennessee, and the older States to the east.

From the first cotton was the money crop of the region. Grown on large plantations, it became the principal resource of the State, and the labor knew nothing of the cultivation of any other crops except such as were grown for home consumption.

During the civil war agriculture was brought almost to a standstill. The hardships of this struggle fell with great force upon the Jackson area, for in the two attempts to reduce Vicksburg various battles were fought in this region, attended with the usual destruction of property by the troops of both sides. Out of this condition arose the present system of crop liens and mortgages, which is a great hindrance to the agricultural development of the area. Since cotton was the only money crop before the war, and its culture alone was understood, it became again practically the only crop of the area, and so remains to-day. The other crops produced are for home consumption only.

CLIMATE.

The climate of the region is favorable to a much wider diversification of crops than at present exists. Like those of the Gulf States in general, the winters are mild and short, while the growing seasons are long. Such mild winters, with but little freezing weather, are favorable to early preparation for crops and their cultivation. Snowfalls are light and infrequent. The long growing season makes cotton a logical crop for the region, and suggests also the advantages offered for certain truck crops.

The available data of temperature and precipitation for a series of years show a growing season lasting from about the last week in March to the first week in November; or at least seven months, during which almost any crop may be grown, and eight to nine months for crops resistant to slight frosts.

The following tables are taken from the records of the Weather

Bureau stations at Vicksburg and Crystalsprings, which are located outside the area, but sufficiently near to show the conditions therein:

Normal monthly and annual temperature and precipitation.

Month.	Vicksburg.		Crystalsprings.		Month.	Vicksburg.		Crystalsprings.	
	Temperature.	Precipitation.	Temperature.	Precipitation.		Temperature.	Precipitation.	Temperature.	Precipitation.
	° *F.*	*Inches.*	° *F.*	*Inches.*		° *F.*	*Inches.*	° *F.*	*Inches.*
January	47.3	5.54	47.7	5.79	August	80.1	3.52	80.3	4.50
February	52.6	4.65	48.4	5.30	September	75.3	3.49	76.2	2.42
March	58.0	6.45	58.3	4.66	October	65.3	2.62	66.6	2.49
April	65.3	5.86	65.7	4.58	November	55.4	4.85	56.5	2.98
May	72.6	4.94	73.6	4.02	December	50.6	4.96	48.3	5.96
June	79.2	4.31	79.7	5.04	Year	65.3	55.66	65.3	53.96
July	81.3	4.47	81.5	6.22					

The following table gives the dates of occurrence of the first killing frost in fall and the last in spring for a series of years:

Dates of first and last killing frosts.

Year.	Vicksburg.		Crystalsprings.		Year.	Vicksburg.		Crystalsprings.	
	Last in spring.	First in fall.	Last in spring.	First in fall.		Last in spring.	First in fall.	Last in spring.	First in fall.
1892	Mar. 2	Nov. 11	....	Nov. 10	1899	Mar. 7	Nov. 3	Mar. 29	Nov. 3
1893	Apr. 22	Nov. 15	Mar. 30	Oct. 15	1900	....	....	Apr. 1	Nov. 4
1894	Mar. 29	Nov. 11	....do...	Oct. 9	1901	Mar. 16	Nov. 16	Apr. 21	Nov. 6
1895	Mar. 17	....do...	Mar. 21	Oct. 21	1902	Mar. 6	Dec. 6	Mar. 18	Oct. 29
1896	Mar. 20	Nov. 9	Apr. 3	Nov. 6	1903	Feb. 19	Oct. 25	Mar. 26	Oct. 19
1897	Feb. 27	Nov. 17	Feb. 27	Nov. 17					

PHYSIOGRAPHY AND GEOLOGY.

The general topography of the Jackson area is rolling to hilly, with a variation in altitude of from 200 to 250 feet between the Pearl River and the highest hilltops. The lower elevations occur along the Pearl River, from which there is a rise both eastward and westward. To the west this rise ends in a ridge which crosses Hinds and Copiah counties in a general north and south direction, forming the divide between the Pearl and Black river drainage systems. It is along this ridge and in the southern part of the area, in Simpson and Copiah counties, that the hilliest sections are encountered, though around the headwaters of all the streams it is more or less hilly.

The Pearl River receives the greater part of the drainage of the area, which it crosses without much fall. It is not a navigable stream, except at high water, though in former times considerable traffic went up and down stream from Jackson in small, light-draft scows and flatboats. The drainage system of the Black River within this area is similar to that of the Pearl River.

The streams of the area are peculiar in that, while they occupy, except in their extreme headwaters, rather broad and mature valleys, they flow in trenchlike depressions in the valley bottoms, with a level overflow strip on each side. These ditchlike courses are from 4 to 15 feet in depth, and during periods of normal flow the streams occupy only the narrow bottoms of the trenches. During heavy rains, however, they rise rapidly and overflow their banks on each side.

The geology of the area is comparatively simple. The materials consist of sediments laid down in a northward extension of the Gulf of Mexico at a time when that body of water reached to or beyond the Tennessee line. These deposits belong to the geological series composing the Gulf Coastal Plain, of which the whole State of Mississippi is a part.

The underlying deposits are the oldest, though still comparatively young from a geological standpoint. They belong to the Jackson Eocene of the Tertiary period, as shown by their fossil-bearing beds. The Jackson Eocene is quite variable in lateral extent, but consists generally of alternate beds of clay, sand, sandy clay, impure limestone, and shell marl. These beds contain large quantities of fossil shells and lime concretions. In the clay beds are frequently found impressions of plant remains.

Overlying the Eocene beds is a series of cross-bedded sands, gravel, and clay, belonging to the Lafayette formation, first described and named by Hilgard in Lafayette County, Miss. This formation consists for the most part of red, orange, or yellow sands, though laterally the sands may grade into various-colored sticky clays, or even into beds of almost pure gravel. Both sands and clays may or may not contain gravel, the pebbles of which consist largely of chert and quartz, with occasional fragments of petrified wood. The Lafayette outcrops everywhere in road cuts and washes, where it may be seen as sands and clays 6 to 50 feet thick, complexly cross-bedded and of various colors, ranging from white to Indian red. It does not, however, enter into the formation of the soils of the area to any important extent.

The surface deposit overlying the Lafayette consists of a blanket of brown silty loam from 3 to 20 feet thick. The origin and geological age of this deposit are still unsettled problems, but it is undoubtedly as recent in age as the Quaternary. It is called loess, because of its resemblance to certain deposits bearing that name found in the valley of the Rhine and in China. The material consists of homogeneous yellow to brown fine-grained silty loam, and shows no evidence of stratification. Where most typically developed, the loess is characterized by its property of weathering into perpendicular bluffs and banks—which peculiarity is due to a system of vertical lines of weakness—and by the presence of lime concretions and land or fresh-water shells. Both the latter, however, may be lacking, as in the present area. The loess is thickest and most typical along the Chickasaw Bluffs, its western boundary in the State, growing thinner and less typical to the eastward. It is from this loess that the soils of the Jackson area are almost entirely derived.

SOILS.

The soil conditions within the Jackson area are remarkably uniform. But three different types were encountered, and such variations as exist in the soils are due to rain wash and erosion.

Areas of different soils.

Soil.	Acres.	Per cent.
Memphis silt loam	410,624	87.1
Meadow	60,736	12.9
Norfolk fine sand	320	....
Total	471,680	....

MEMPHIS SILT LOAM.

The soil of the Memphis silt loam consists of from 6 to 12 inches of brownish-yellow to gray silt loam, underlain by heavier brown to chocolate-brown silt loam. The soil when wet is very sticky and plastic, acting in some respects like clay, but when dry it crumbles into a flourlike dust. When plowed too wet it has a tendency to cake into clods, which do not readily break down.

The variations which occur in this type are due for the most part to erosion by rainwater, which, on hillsides and even on slopes of moderate inclination, works with great rapidity. The result of this wash is to make deep trenches across fields or gradually to remove the soil, leaving the subsoil exposed. Frequently the gullies thus produced are many feet in depth, and reach down to the underlying sand of the Lafayette, which is then washed out and down the hillside. Occasionally the top of a steep hill will have its covering of loam entirely removed, leaving an area of sand or gravel generally too small to indicate upon a map of the scale used. Whenever wash has been excessive on a steep slope it is usual to find the soil deeper at the foot and almost or quite removed at the top, where the subsoil is often exposed.

In the valley bottoms and along the lower slopes of the Pearl River there occur areas in which both the soil and subsoil are gray in color and contain many iron concretions about the size of peas. This variation is known locally as "white buckshot land." Most of it is poorly drained and much has been mapped as Meadow.

The Memphis silt loam occurs over a great part of the area, covering the hilltops and valley sides alike, except where removed in small spots by erosion. It is a peculiar soil in its drainage features, acting in this respect like an impervious clay. The rainfall is absorbed very slowly, and much of it rushes away into the streams, thus increasing the tendency to wash. So slowly does water penetrate this type that ponds are made for the purpose of watering cattle by simply building a slight dam across a depression, which will thus retain water for long periods, losing more by evaporation than by absorption. Much of this soil would undoubtedly be benefited by tile drainage. Open ditches are beneficial on level areas, where, owing to the tendency of the soil to stand in vertical banks, they do not fill up so rapidly as in other soil types.

The Memphis silt loam is derived from loess through the ordinary processes of weathering.

The crops grown on this type in the Jackson area are chiefly cotton and corn, the former being the sole export crop. Other crops, such as sweet and Irish potatoes, sugar cane, and vegetables, are grown for home consumption. The average yield per acre of cotton is one-half bale or less, while that of corn is from 15 to 30 bushels.

The Memphis silt loam is undoubtedly suited to a wider range of crops than those at present produced. It seems especially adapted to Bermuda grass, some of which is at present grown, though not so much as its importance demands. A wider extension of forage crops, such as Bermuda grass, cowpeas, and Japan clover, and more attention to the production of cattle and hogs are to be recommended as substitutes for exclusive cotton growing. All sorts of vegetables do well upon this type of soil, and a few small peach orchards show the possibilities of fruit growing with more careful cultivation and attention. The growing of early potatoes for the northern market also promises good returns.

The following table gives the mechanical analyses of this soil:

Mechanical analyses of Memphis silt loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10646	2 miles SE. of Florence.	Yellow silty loam, 0 to 8 inches.	0.0	0.2	0.2	0.8	9.0	79.4	10.2
10642	3 miles W. of Jackson.	Yellow silty loam, 0 to 12 inches.	.0	.6	1.9	11.0	4.1	59.1	23.1
10644	4 miles W. of Terry.	Yellow silty loam, 0 to 8 inches.	.2	1.3	.6	.8	4.1	67.5	25.4
10645	Subsoil of 10644 ..	Yellow silty loam, 8 to 36 inches.	.1	.5	.4	.5	5.4	73.8	19.2
10643	Subsoil of 10642 ..	Brown silty loam, 12 to 36 inches.	.1	.7	2.5	14.4	4.4	57.3	20.8
10647	Subsoil of 10646 ..	Brown silty loam, 8 to 36 inches.	.5	1.4	.6	.7	3.7	72.5	20.5

NORFOLK FINE SAND.

The Norfolk fine sand consists of from 6 to 8 inches of gray to yellow sand underlain by white or orange sand. There is little difference between soil and subsoil, except that the former is generally richer in organic matter.

This type is found chiefly in small patches, too small to be shown on a map of the scale used, but one large area, about half a mile in extent, occurs east of the Pearl River, in Rankin County.

The Norfolk fine sand is for the most part in forest, being considered too poor for corn and cotton, and, as a rule, is too badly gullied to be of any agricultural importance.

The soil is derived from the Lafayette deposits uncovered through erosion of the Memphis silt loam.

The following table gives mechanical analyses of this type:

Mechanical analyses of Norfolk fine sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
10650	5 miles E. of Jackson.	Medium sand, 0 to 10 inches.	0.3	2.7	16.4	47.9	10.0	21.0	1.6
10648	5 miles E. of Jackson.	Gray sand, 0 to 12 inches.	.0	.8	8.9	58.8	6.2	20.5	4.8
10651	Subsoil of 10650 ..	Medium sand, 10 to 36 inches.	.0	1.8	19.2	47.3	9.4	19.3	2.9
10649	Subsoil of 10648 ..	Gray sand, 12 to 36 inches.	.2	1.1	8.8	53.4	6.5	23.0	7.1

MEADOW.

The Meadow in the Jackson area consists of low-lying, poorly drained soils bordering stream courses, and varying in texture from true Memphis silt loam to sand. It is subject to overflow at every heavy rainfall, and is known locally as "bottom land."

It is most extensively developed along the Pearl River, where it varies from 1 to 4 miles in width. Its surface is uniformly flat, and water collects in pools upon it after every rain. While the streams are at their normal level, however, this surface water might be quickly carried off by ditching, for the surface of these bottoms lies, on an average, from 6 to 15 feet above normal water level.

The Meadow is formed of sediments washed from the valley slopes by the rains and deposited by the streams along their banks. The soil consists largely of silt, and does not vary in important details of texture from the Memphis silt loam, except where, nearer the stream channels, it is occasionally sandier. However, it contains the surface wash from the uplands, and is thus much richer in organic matter than the Memphis silt loam and gives larger yields of all crops.

Recently the Meadow along the smaller creeks has been planted extensively to cotton, giving an average yield of 1 bale per acre. This cotton, however, is later than that on the hills, as it is necessary to wait for the passing of the spring floods before planting, and even then it is frequently necessary to replant on account of overflows. Bermuda grass, being uninjured by these overflows, is especially adapted to this type of soil.

Much of the Meadow now contains dense canebrakes, which furnish good pasturage for cattle, and other areas not fit for cultivation might well be allowed to grow up in cane.

The large areas of Meadow along the Pearl River are now mostly in forest, with an undergrowth of cane and wild grasses. Parts of this area are high enough to be flooded but a few inches, and such areas are usually cultivated, the same crops being grown as on the Meadow bordering the smaller streams.

AGRICULTURAL METHODS.

The agricultural methods in use in the Jackson area admit of great improvement, the present system and practice in a majority of cases resulting in small returns and much economic waste. Cotton and corn are sometimes grown alternately, or the former is grown year after year until the yield drops to the minimum. The land is then allowed to lie idle, becoming gullied by erosion, while new land is brought under cultivation by the wasteful method of girdling the standing timber. In some instances, however, there is a liberal use of commercial fertilizers, which act as a stimulant for the immediate crop, but leave the soil finally in as unproductive a condition as does the other method of constant cropping without rotation or manure.

Some of the more advanced planters have adopted more or less complete systems of crop rotation, but they form only a small minority of the total number.

One of the principal causes for the continuance of the imperfect methods above noted is the mortgage or crop-lien system. Under this the tenants are provided with food and implements with which to grow a cotton crop; and they, having no capital themselves and not owning the land, crop it to exhaustion and then move to new land elsewhere.

In the majority of cases in this area plowing is done with one mule, and the plows commonly used are incapable of stirring the soil to a sufficient depth. Larger plows are coming into use, however, and it is to be hoped that they will in time supplant the present inadequate implements. Deep plowing will undoubtedly improve the soils of this area, and in many cases subsoiling is recommended. This, with a system of rotation with legumes, will greatly improve conditions.

AGRICULTURAL CONDITIONS.

As a rule, the owners of large estates which are farmed in small parcels by tenants are in a prosperous condition, but the state of the farmers of small areas leaves much to be desired.

The system of rental is as follows: The planter furnishes the tenant with tools, stock, and provisions, taking a lien on the stock and prospective crop to insure his rental and the repayment of any advancements made. The tenant then produces as much cotton as his own industry and prevailing conditions will permit, out of which the landowner gets his rent money and any other debts due him. Owing to the limitations of yield and the area which can be cultivated, the tenant seldom has anything to show for his year's labor after the disposal of the cotton. There are exceptional cases where tenants have made and saved money and now own farms, but they are few in number.

Most of the farm lands are held free from mortgage, it being more common to borrow money on the future crop than on the land itself. Farms vary greatly in size, ranging from 40-acre plots to plantations of 1,000 or more acres.

Farm labor is not so dependable or skillful as could be wished. It is therefore difficult to farm with day labor alone. These labor conditions are a chief cause of the continuance of the crop-lien and rental system, and form one of the great drawbacks to the introduction of special crops and better methods of agriculture.

Cotton is the principal crop, and all other crops now grown are subsidiary to it. Corn is grown as feed for horses and mules, but there is not always enough to meet the farm demands. Other forage and feed crops now grown are Bermuda grass, cowpeas, peanuts, and some oats. The production of these crops, however, is insufficient properly to carry the stock through even the short, mild winters of the region. Some sugar cane is grown for the making of sirup for home consumption.

The luxuriance with which Bermuda grass, cowpeas, Japan clover, and cane grow on the Memphis silt loam indicates that the cattle-raising industry could be easily and profitably extended in the Jackson area. Truck would undoubtedly do well if reliable and efficient labor could be obtained, and fruit, especially peaches, gives promise of success. Pecans also do well in this area.

Four railroads center at Jackson—the Illinois Central, the Queen and Crescent, the Yazoo and Mississippi Valley, and the Gulf and Ship Island lines. They afford unusually good shipping connections with the markets of the North, East, South, and West. One or another of these roads runs within easy reach of every part of the area.

Jackson is the only local market of any importance for farm products other than cotton, but the steady increase of manufacturing and other industries throughout the South gives promise of better and more prosperous conditions for this agricultural area in the near future.

SOIL SURVEY OF THE BILOXI AREA, MISSISSIPPI.

By **W. EDWARD HEARN** and **M. E. CARR.**

LOCATION AND BOUNDARIES OF THE AREA.

Harrison County is the middle Gulf coast county of Mississippi, and is bounded on the north by Perry County, on the east by Jackson County, on the south by Mississippi Sound—an arm of the Gulf of Mexico—and on the west by Pearl River and Hancock counties.

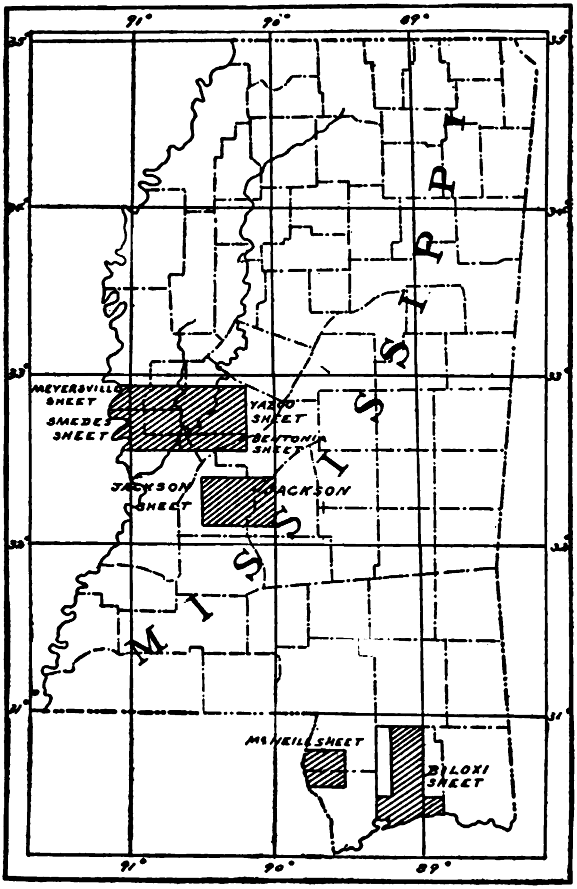

FIG. 14.—Sketch map showing location of the Biloxi area, Mississippi.

The area surveyed is T-shaped, and comprises about two-thirds of the county (393,920 acres, or about 615 square miles). It includes a strip across the southern part of the county, ranging in width from

8½ miles on the eastern side to 15 miles on its western border, and with a length east and west of about 27 miles; and also two tiers of townships lying in the central part of the county and extending north to the Perry County line. The area is included between the parallels of 30° 15′ and 30° 55′ north latitude, and the meridians of 88° 46′ and 89° 16′ west longitude.

Biloxi, situated in the extreme southeastern part of the area, is a summer and winter resort and the largest town within the area, while Gulfport is the county seat and is growing rapidly. Pass Christian is also a summer and winter resort. McHenry, Wiggins, Bond, Lyman, Howison, and Saucier are the principal lumber towns in the interior of the county, while Longbeach, situated on the coast, is now the center of the trucking industry of the area.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Hancock County was formed in 1812, and about 1840 a division was made, the eastern part being organized as Harrison County, with the county seat at Mississippi City, where it remained until the autumn of 1903, and was then removed to Gulfport. Other early settlements were located at Wool Market and Pass Christian. The attention of the early settlers, as well as of a large number of the present inhabitants, was given to fishing and the catching of oysters, both being excellent along the coast and in the estuaries of the Gulf. Although two centuries have passed since the settlement of d'Iberville, very little agricultural development has taken place. In the interior of the county some very old settlements are seen; yet only small areas have been cleared, and the owners grow no crops except for home use. Corn, oats, and similar crops are grown, but only to a limited extent. About 1840 some Sea Island cotton was grown in the vicinity of the Bay of Portage with a fair degree of success, but owing to the difficulty of ginning this industry did not become established. Some cotton has been grown in the interior of the county, but the low yield has prevented the planting of a large acreage.

The open range and mild climate have contributed to the success of stock raising, the chief agricultural source of income in the interior. Formerly considerable quantities of wool were marketed and shipped by schooner from Wool Market, this giving the settlement its name. A large portion of the wool shipped from this point was produced to the north and northwest of the county, and the building of the New Orleans and Northeastern Railroad in 1871 diverted the shipping to points along that road. Recently considerable attention has been given to the growing of truck along the coast.

Until the Louisville and Nashville Railroad was built, in the early seventies, no transportation was afforded the products of the county except by schooner to New Orleans and Mobile.

The interior of the county was formerly one vast forest of long-leaf pine. Since the completion, in 1897, of the Gulf and Ship Island Railroad from Gulfport to Hattiesburg many large sawmills have been built along its line, towns have been started, and the population has been considerably increased. Scarcely any attention, however, is given to agricultural pursuits, vegetables from other States being shipped into the area and sold in these sawmill towns at fancy prices. The people, as a class, are engaged in the production of lumber, charcoal, and turpentine, all of which are shipped from Gulfport.

CLIMATE.

The climate of the Biloxi area is that of the warm temperate zone. Bordering the Gulf of Mexico the climate is tempered by that great body of water, thus giving a more uniform temperature than is found farther north in the State.

The records of the Weather Bureau stations at Biloxi, Bay St. Louis, and Hattiesburg represent fairly well the climatological conditions in the area. Bay St. Louis lies near the coast, just west of the area surveyed, while Hattiesburg is about 25 miles north of the area. Two tables are presented, one showing the normal monthly and annual temperature and precipitation, and the other the dates of the last killing frost in spring and the first in fall. The hottest months are June, July, and August, with an average temperature of about 81° F. along the coast and 83° F. through the interior of the county. The coolest months are December, January, and February, with an average temperature of 51° F.

Normal monthly and annual temperature and precipitation.

Month.	Biloxi.		Bay St. Louis.		Hattiesburg.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	° F.	*Inches.*	*° F.*	*Inches.*	*° F.*	*Inches.*
January	50.9	4.08	50.3	6.14	49.6	4.31
February	52.7	6.51	53.1	5.38	52.4	4.85
March	61.1	6.86	61.4	5.49	61.0	3.51
April	67.1	3.94	67.2	7.09	66.3	3.58
May	75.1	3.28	75.2	2.05	74.4	2.21
June	80.0	7.96	82.1	7.28	81.1	5.81
July	81.8	5.53	81.5	6.48	82.1	6.28
August	81.0	7.97	81.1	8.81	81.9	5.27
September	77.3	6.70	78.8	4.54	77.8	2.21
October	68.2	3.47	69.1	2.52	67.1	1.42
November	58.5	2.99	59.7	2.98	57.7	3.08
December	51.3	4.88	51.8	4.98	51.9	4.28
Year	67.1	64.17	67.6	63.24	66.9	46.81

Dates of first and last killing frosts.

Year.	Biloxi.		Bay St. Louis.		Hattiesburg.	
	Last in spring.	First in fall.	Last in spring.	First in fall.	Last in spring.	First in fall.
1894	Mar. 26	Dec. 26	Mar. 27	Dec. 27	Mar. 30	Nov. 12
1895	Mar. 2	Nov. 26	Mar. 3	Dec. 4	Mar. 21	....
1896	Feb. 21	Nov. 30	Feb. 18	Dec. 25	....	....
1897	Jan. 29	Dec. 4	Feb. 2	Dec. 5	Feb. 28	Nov. 30
1898	Mar. 4	Oct. 22	Feb. 22	Nov. 28	Feb. 23	Oct. 27
1899	Feb. 13	Dec. 14	Mar. 7	Dec. 16	Mar. 7	Nov. 3
1900	Feb. 18	Nov. 13	Feb. 19	Nov. 13	Mar. 17	....
1901	....	Nov. 17	Mar. 16	Nov. 17	....	Nov. 16
1902	Mar. 6	....	....	Dec. 5	Mar. 6	Nov. 28
1903	Feb. 18	Nov. 19	....	Nov. 19	Feb. 24	Oct. 25
Average	Feb. 24	Nov. 26	Feb. 28	Dec. 3	Mar. 9	Nov. 11

The rainfall is abundant, averaging near the Gulf about 63 inches annually, and somewhat less in the northern part of the area, judging from the records at Hattiesburg, where the normal precipitation is almost 47 inches. The rainfall is fairly well distributed throughout the year, and crops seldom suffer seriously from drought during the spring and early summer. The relative humidity, as well as the rainfall, is greater along the coast than in the northern part of the county.

In 1899 there occurred a period of unusually cold weather. The few orange trees in the area and many fig trees were killed. The latter have grown up again and are bearing fruit, but oranges are no longer grown on a commercial scale. As a general thing the winters are so mild that all kinds of farm labor can be carried on throughout that season. Many vegetables can be grown during the winter, while all kinds of truck are successfully produced in the late winter and early spring, and put on the market just after the Florida, Louisiana, and southern Texas crops. Cattle find good grazing from February to December, and many throughout the year have no feed except what they get from the range. Sheep are also raised at little or no expense to their owners. Poultry raising can be carried on successfully during the entire year.

On account of the mild climate many northern people spend the winter months here, while a number of New Orleans residents have summer homes along the coast.

PHYSIOGRAPHY AND GEOLOGY.

That portion of Harrison County included in the present survey lies within the Gulf Coastal Plain. The drainage of the area is accomplished by four separate systems. The Red River, a branch of the Pascagoula, flows across the northern part of the area in a southeasterly direction. It has cut so deep a channel that the smaller streams flowing into it can easily carry off any excess of precipitation. A little farther to the south the Big Biloxi and Little Biloxi rivers extend across the area in a similar direction and unite about 2½ miles above Wool Market, forming Oakchambula Bayou, an arm of the Back Bay of Biloxi. In the southwestern part of the area is the Wolf River, which flows southeast until about 5 miles from the coast, where it turns sharply to the southwest and empties into the Bay of St. Louis. In the southeast Cabawfa Creek flows southeast and empties into the Tchula River at a point near the Jackson County line. From here the Tchula flows west and empties into the Back Bay of Biloxi near the mouth of Oakchambula Bayou. Except along their lower courses, where they reach the level of tide water, all of these last three systems, with their tributaries, have sufficiently rapid currents quickly to remove any surplus of surface water.

In the area surveyed two distinct physiographic divisions are easily recognized—the lowlands or level country along the coast and large streams, and the uplands or rolling, broken country in the interior. These rolling uplands make up about three-fifths of the area, and are found at an average distance of about 5 miles from the coast. They extend to the northern boundary of the county and beyond. To the east and west they also pass beyond the limits of the county.

The topography of these uplands is very rolling and broken, there being scarcely any level country except to the east of Wiggins, where the area surveyed extends to and includes a few square miles of comparatively level country, known locally as the "Big Level." This level seems to be a remnant of the plateau as it appeared when first raised above the tides and before it had been so excessively carved by erosive agencies. It extends for an undetermined distance to the east, though it can not be far, since the valleys of the Pascagoula River and its western tributaries are not far distant. The elevation of the upland division varies considerably. The highest point of which any data could be obtained is at Bond, near the northern boundary of the area. Here the elevation above tide water is 306 feet. The lowest point given in the data at hand is at Nugent, and is only 84 feet above tide level. Along the southern border, where the uplands meet the coastal lowlands, the elevation is considerably less. The uplands do not exist as one continuous body, but are separated by the river lowlands into five different ridges or interstream areas, the largest being that between the Red and the Big Biloxi rivers and the smallest that between the Little Biloxi and the Big Biloxi rivers.

The soils of the uplands consist of sands and sandy loams, which are somewhat lighter to the north of the Big Biloxi River. Owing to their elevation above the stream courses and to their uneven surface, they have excellent drainage. On some of the lighter soils it is excessive, the subsoil being of such a texture as to allow a rapid percolation of the meteoric waters to lower levels, leaving the surface deficient in moisture shortly after a heavy rain.

Numerous small streams are found during wet weather, but when droughty conditions exist all but a few of the largest become dry. Springs are few and good drinking water scarce. Artesian water, it seems, can not be easily secured, as there is but one such well in the upland section, that being at the sawmill at Lyman, toward the southern border.

The lowlands may be considered in two divisions: First, the flat coastal section; second, the bottoms along the larger streams.

The coastal lowlands have a level or slightly undulating surface. They extend not only across the entire southern portion of Harrison County, but also across all three of the coast counties of the State. This level country extends inland about 5 miles. At Gulfport the elevation is 25 feet, while in the vicinity of the mouth of Wolf River, Bay of Portage, and the lower course of the Tchula River quite extensive areas lie at about tide level and consist of low, level, and marshy bottoms covered with vegetation peculiar to salt marshes. It will thus be seen that the elevation of the coastal section varies from sea level to about 25 feet, the higher portion lying along the coast.

The southwestern corner of the county is indented by the Bay of St. Louis. This indentation, with the Bay of Portage, forms a peninsula about 4 miles long by 2 miles wide, on which Pass Christian is located.

The southeastern corner of the county is indented to a more marked extent by the Back Bay of Biloxi. This arm of Mississippi Sound cuts into the land in a northerly direction, then abruptly turns to the west and extends for a distance of nearly 10 miles. It varies in width from three-fourths of a mile at the Biloxi toll bridge to nearly 2 miles at its western end. The peninsula formed by this indentation is nearly 2 miles wide, the city of Biloxi being located at its eastern end. From the fact that streams flowing into these two indentations have their sources near each other and that the country inland lying between them is lower than that along the coast, it may be inferred that at some former time they were connected, making of the present coast country a long, narrow island. The streams have built up the land, joining the island to the mainland and separating the two arms of the sea, by the deposition of sediments, which process is still going on in the Back Bay of Biloxi and the Bay of St. Louis.

The soils of the coastal lowlands are fine sands. The inland portion, as stated, is somewhat lower, and the sands are finer and more silty than those along the coast.

The drainage of this subdivision of the lowlands is fairly good, except for local low places and some of the finer sands inland, as well as the low, marshy places previously mentioned. The only good water for domestic use is secured by drilling artesian wells. An excellent and abundant supply can always be obtained at depths ranging from 675 to 925 feet, the wells always flowing.

The river lowlands occur in more or less narrow strips along the Wolf, Tchula, Red, Little Biloxi, and Big Biloxi rivers, Oakchambula Bayou, Cabawfa Creek, and a few of their tributaries.

Although the topography of these lowlands is similar to that of those along the coast in that it is level or slightly undulating, the elevation is widely different. Along the lower courses of the streams, where they emerge from the rolling upland, the elevation is about the same as that of the coastal lowland, the streams being navigable for schooners for short distances inland. In the vicinity of Wortham, along the Big and Little Biloxi rivers, it is about 65 feet, while it increases gradually as the streams are ascended. Near Perkinston, on the Red River, it is about 110 feet. The streams have cut deep channels through these lowlands, thus giving a better drainage than might naturally be expected. This fact tends to show that a second elevation has taken place and that the streams are endeavoring to reach their new base level.

The geological formations in Harrison County, from which the soils are derived directly by processes of weathering and erosion, are, in the upland portion of the county, the Lafayette of Quaternary time, consisting of unconsolidated reddish, gray, and yellow sands and clays, and in the lowlands the more recent sediment.

In many places in the Lafayette iron concretions and crusts have been formed by the oxidation of the infiltrating iron salts. Small, iron-stained quartz gravel is quite generally scattered over the surface of this formation, in a few places forming beds indicating swifter currents in some portions during the deposition of this material. Scattered through the central and northern parts of the county are small areas of fine wind-blown sand. The largest of such areas is about 2 miles east of Howison, where the sand is about 20 feet deep and rests directly upon the heavier material of the formation.

There is some evidence that the Port Hudson deposits outcrop in the vicinity of the Wolf River, but as the soils do not seem to be influenced thereby they will not be discussed here.

The lowlands previously described consist of fine sands and silt, or the recent deposits of alluvium. They belong to the latest of the Quaternary deposits—the Columbian. The term "Biloxi Sands" has been proposed for this division of the Columbian in this region.

SOILS.

There were recognized and mapped in the Biloxi area five soil types, exclusive of Meadow. The area and proportionate extent of each of these types are shown in the table given below:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Norfolk fine sandy loam	171,968	43.6	Meadow	17,600	4.5
Norfolk sand	76,082	19.3	Orangeburg fine sandy loam	3,008	.8
Norfolk loam	68,416	17.4			
Norfolk fine sand	56,896	14.4	Total	393,920	

NORFOLK FINE SANDY LOAM.

The Norfolk fine sandy loam is the most extensive of the soil types mapped in the Biloxi area. The surface soil for the first 8 to 12 inches consists of a mealy gray fine sandy loam. In some localities it contains iron concretions and quartz gravel, thus giving it the local name of "buckshot" land. Near the border between this type and the Norfolk sand the soil is more sandy than in the typical areas, and the two types gradually merge into each other.

The subsoil of this type to a depth of 36 inches is a yellowish or reddish friable sandy clay. Some areas of it grade into a stiffer mottled clay at about 30 inches, while there are local spots where the subsoil is more nearly a heavy sandy loam.

The Norfolk fine sandy loam is found in all parts of the area surveyed. The largest areas occur east and west of the Wolf River, in the vicinity of Nugent, Lyman, Millview, and many other places along the Gulf and Ship Island Railroad. A large area is also found east of Wool Market, and many scattered areas are seen elsewhere throughout the county.

This soil type occupies the gently rolling, rolling, and even hilly areas of the upland portion of the area. The broad, rolling areas are very well situated for farming purposes. The steeper slopes occupied by this type are found in the northern part of the area surveyed, where the small streams have their sources. However, none of this soil is so rolling as to prevent successful cultivation. The elevation of the areas of this soil type ranges from 25 to 306 feet above sea level.

The drainage of the type is very good. The rolling character of the surface gives it good superficial drainage, while the friable character of the subsoil is such that underdrainage is quite free. It is seldom necessary to use ditch or tile drains in the areas of this soil type.

The Norfolk fine sandy loam owes its origin to the weathering of the yellow sandy clays of the Gulf Coastal Plain. The action of rain water has taken quite a large amount of clay from the surface soil, leaving it with a higher percentage of sand than the underlying subsoil stratum. This type is developed largely by erosion, and near the small streams the surface soil is usually more sandy, showing that the fine material has been washed out and carried away. In a few places the entire sandy mantle of the surface soil has been eroded, leaving the sandy clay or stiff, mottled clay exposed.

Only a very small proportion of the Norfolk fine sandy loam is cultivated, the greater part of it being forested with a scattering growth of longleaf pine. From about two-thirds of the type the merchantable timber has been cut. The remaining one-third is still heavily timbered and in some places extensive turpentine orchards are seen. The areas cleared and cultivated produce only ordinary yields of corn, oats, cotton, and sugar cane, but good yields of potatoes, garden vegetables, and fruits. The few peach orchards seen on this type show that the soil is admirably adapted to the growing of this fruit on a commercial scale. Figs, pecans, plums, and pears are also successfully grown. Blackberries and strawberries do well. Sugar cane and some of the grasses make a fair growth in this soil, but the production of these crops is recommended only to supply home needs or local trade. Cotton produces from one-third to two-thirds of a bale per acre.

While the Norfolk fine sandy loam is not a typical general farming soil, it is well adapted to the growing of peaches, small fruits, berries, and tomatoes, and to the production of late truck. Pears do well, although they soon blight. This soil is worth from $3 to $15 an acre, depending on distance from the towns and railroad facilities.

Below are given the mechanical analyses of the Norfolk fine sandy loam:

Mechanical analyses of Norfolk fine sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10733	1 mile NE. of Wool Market.	Fine sandy loam, 0 to 10 inches.	1.6	8.2	15.5	21.5	22.2	24.8	6.1
10731	3 miles NE. of Wiggins.	Fine sandy loam, 0 to 12 inches.	.2	.6	1.4	28.8	27.1	34.9	7.1
10729	1½ miles SW. of Howison.	Fine sandy loam, 0 to 10 inches.	.5	1.4	1.9	23.9	28.2	36.2	7.9
10901	11 miles NW. of Pass Christian.	Fine sandy loam, 0 to 12 inches.	.7	2.6	6.4	37.5	23.7	20.4	8.6
10732	Subsoil of 10731	Yellow sandy clay, 12 to 36 inches.	.1	.4	1.1	25.5	24.1	31.1	17.6
10734	Subsoil of 10733	Yellow sandy clay, 10 to 36 inches.	2.2	5.6	11.1	14.8	14.7	30.5	20.8
10902	Subsoil of 10901	Sandy clay, 12 to 36 inches.	.3	1.6	4.4	30.3	22.2	16.4	24.6
10730	Subsoil of 10729	Sandy clay, 10 to 36 inches.	.3	1.0	1.0	18.3	24.7	28.0	26.5

NORFOLK FINE SAND.

The surface soil of the Norfolk fine sand, to a depth of 8 or 10 inches, consists of a grayish or whitish sand of fine texture and loose, incoherent structure, composed of well-rounded particles. In a few depressed areas where decayed vegetation has accumulated there is quite a little organic matter, but the greater proportion of the type has only a very small percentage.

The subsoil to a depth of 36 inches is yellowish or grayish fine sand, also loose and incoherent. Both the soil and subsoil in some localities contain a high percentage of medium sand. At from 3 to 6 feet this sand grades into a fine white sand, which, along the coast, has a depth of from 20 to 50 feet.

The Norfolk fine sand reaches its greatest development in a large unbroken area extending across the southern part of the county along the Louisville and Nashville Railroad. It borders Mississippi Sound and extends inland to the north for a distance varying from 3 to 5 miles. Many other areas of less extent are found in the vicinity of Lazarus, Lorraine, Landon, Delisle, and to the north of Cuevas, while a small area is mapped about 2 miles east of Howison, and also a spot near Finley.

The surface characteristics of the Norfolk fine sand are very uniform throughout, constituting broad, level to gently rolling and undulating areas of country, whose elevation along the coast ranges from tide water to about 25 feet above. A higher altitude is reached by the areas farther inland, and the area east of Howison is about 175 feet above sea level. Throughout the areas of this soil there occur long, narrow depressions, more or less local, lying a few feet lower than the more typical surrounding areas of the type.

The more elevated and undulating areas of the Norfolk fine sand have very good natural surface drainage, due mainly to the open, loose texture of both soil and subsoil. It is the thoroughly drained condition of this type that makes it an early and warm soil, suitable for the production of truck. The depressions occurring in this type, referred to in connection with its topography, are not well drained, and in some cases have been mapped as Meadow. Some of these depressions could be drained by tile or open-ditch drains. Owing to the texture of this soil and its proximity to the water level, the moisture conditions are superior to those of any other type in the area except the Norfolk loam.

This type owes its origin to recent Coastal Plain deposits of fine sand, which represent the youngest geological formation of the area. Erosive agencies have done little to change the texture of this formation since it was first uplifted from the Gulf of Mexico. In fact, the surface soil is slightly heavier than the subsoil, from the accumulation of the relatively small amount of vegetable matter which it contains; whereas in the types subjected to greater erosion the texture of the surface soil has usually been made more sandy than the subsoil through the removal of the finer particles in the wash. The area of Norfolk fine sand east of Howison consists of wind-blown sand and is underlain, at from 3 to 20 feet, by the materials of the Norfolk fine sandy loam.

The Norfolk fine sand is an ideal soil for early truck, and it is the trucking industry that is making this soil valuable in an agricultural way. Only a small proportion of this type is under cultivation, except in the vicinity of the Louisville and Nashville Railroad and to the north of Longbeach. The soil along the coast front is held at fancy prices, as well as that in the vicinity of the small towns, but the large areas lying north of the railroad can be bought for farming purposes at fairly reasonable prices. A few liveoaks and magnolias are seen on this type near the coast, while the longleaf pine and some pitch pines, together with the scrubby pines which have recently grown up, constitute the timber growth farther inland. The depressed areas are covered with cypress, gum, bay, and other hardwoods.

The crops grown on this type with the best results are radishes, lettuce, beets, cabbage, onions, cucumbers, green peas, turnips, melons, cantaloupes, strawberries, tomatoes in a small way, and early corn. Grass and sugar cane are grown where the land is heavily fertilized, but these crops are not recommended, except for home use. Figs and pecans do remarkably well on this soil, and several orchards were observed. A few peaches, plums, and pears were also seen, but these fruits are better adapted to the soils of the more rolling areas. In general, the Norfolk fine sand offers the best advantages for early truck growing of any type in the area surveyed, not alone because of its texture, but also of the favorable climatic conditions along the coast and the excellent transportation facilities.

Below are given the mechanical analyses of typical samples of the Norfolk fine sand:

Mechanical analyses of Norfolk fine sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10893	½ mile E. of Pass Christian.	Gray fine sand, 0 to 10 inches.	0.1	4.2	12.6	57.6	7.7	14.9	2.6
10895	¾ mile NW. of Gulfport.	Gray fine sand, 0 to 10 inches.	.2	2.1	17.0	68.4	2.0	7.7	2.7
10897	1¼ miles W. of Biloxi.	Gray fine sand, 0 to 8 inches.	.0	1.8	20.8	63.5	2.4	7.8	2.7
10898	Subsoil of 10897	Fine and medium sand, 8 to 36 inches.	.0	1.7	22.5	60.4	2.3	9.2	2.7
10894	Subsoil of 10893	Fine and medium sand, 10 to 36 inches.	.2	4.2	14.7	55.5	6.8	12.6	5.8
10896	Subsoil of 10895	Yellow fine sand, 10 to 36 inches.	.0	1.4	13.8	65.8	1.8	8.9	7.9

NORFOLK SAND.

The Norfolk sand, to a depth of 8 to 12 inches, consists of a gray or brown medium to coarse sand, rather loose and incoherent, and containing comparatively little organic matter. Some few areas of this soil are more nearly a fine to medium sand, being more coherent and compact than the typical occurrences. In some places a few iron concretions and fragments of quartz gravel are found in this soil, and a few small hills of rounded gravel occur.

The subsoil, to a depth of 36 inches, is a medium to coarse sand, loose and incoherent and of a reddish or grayish color. It also contains some quartz gravel. In many places the subsoil contains a sufficient amount of clay to cause it to be sticky and to cohere, and when exposed to the sun it bakes and has the appearance of a friable clay. In other instances the subsoil, below 30 inches, grades into a sandy clay. These places are near the boundary between this type and the Norfolk fine sandy loam.

The Norfolk sand occurs in broad, extended areas, running in a general north and south direction through the northern and central parts of the area surveyed. It is found most typically developed in the vicinity of Airey and McHenry, to the west of Ten Mile, around Wiggins, and along the Gulf and Ship Island Railroad. The largest area begins at Ten Mile, passes through Airey, and reaches the lowlands along the Biloxi River. Many smaller disconnected areas were also mapped in the northern and central portions of the county.

The surface features of the Norfolk sand are broken and varied. It occupies the hilly and very rolling areas with an elevation of from 150 to 306 feet, and the less rolling areas bordering a few of the stream courses and lowlands where the elevation ranges from about 90 to 130 feet above tide water. Around McHenry, Airey, Wiggins, and in a few other places the country is very rolling and hilly, constituting the roughest part of the area surveyed.

Owing to its rolling surface and the loose, open character of the subsoil the Norfolk sand has exceptionally good drainage. Indeed, drainage is so thorough and the rainfall seeps away so rapidly that the soil is soon deficient in moisture and crops are likely to suffer from lack of moisture even in ordinary seasons. All kinds of farm work can be carried on immediately after a rain. This soil is subject to serious erosion, and considerable care should be exercised in its management to prevent the surface soil from being washed away.

The Norfolk sand probably owes its origin to the weathering of the more sandy clays and sands of the Lafayette formation. The fact that the mineral particles of soil are coarser than the surrounding soil type indicates that it was deposited by swifter-flowing currents. The few beds of gravel were also deposited in the same way. Erosive agencies have played an important part in the formation of this soil by washing out the greater part of the clay and silt usually found in the materials of the Lafayette in this area.

Agriculturally speaking, the Norfolk sand is not a very productive soil. Until recently the greater part of this type was covered with a fairly good growth of longleaf pine, but at present most of the marketable timber has been cut and the area occupied by this soil presents a rather desolate appearance. A few small farms and here and there abandoned fields and cabins occur. The crops grown are: Corn, with a small yield; cotton, giving about one-third of a bale per acre; potatoes, sweet potatoes, berries, peaches, and all kinds of garden vegetables. The soil is too light for general farming purposes, but if heavily fertilized garden vegetables, peaches, plums, blackberries, potatoes, tomatoes, and melons do well in favorable seasons, and these crops are recommended. Some excellent gardens were seen.

The Norfolk sand is an early and easily tilled soil and one which can be readily improved by adding organic matter in some form, as by turning under some leguminous crop or by applying decaying pine needles, which may be had in large quantities. These substances make the soil more loamy and more retentive of moisture.

Much of the Norfolk sand can be bought for $1 an acre or less, but the better portions are held at from $3 to $5 an acre, depending on location. These prices only apply to land from which the merchantable timber has been cut, as the timber lands are worth from $10 to $25 an acre.

The following table gives mechanical analyses of the Norfolk sand:

Mechanical analyses of Norfolk sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10633	1 mile E. of Wiggins.	Fine and medium sand, 0 to 12 inches.	0.3	3.1	15.2	52.6	10.5	12.7	5.6
10908	1 mile S. of McHenry.	Medium to coarse sand, 0 to 9 inches.	1.5	35.3	30.0	10.6	4.3	12.2	6.1
10635	2¼ miles W. of Perkinston.	Gray medium sand, 0 to 9 inches.	.3	6.7	25.4	38.3	6.1	16.3	6.9
10904	Subsoil of 10908	Medium to coarse sand, 9 to 36 inches.	3.2	36.7	26.2	10.0	4.8	13.7	5.0
10636	Subsoil of 10635	Medium loamy sand, 9 to 36 inches.	1.6	6.4	23.8	34.5	5.2	16.5	11.7
10634	Subsoil of 10633	Brown medium clayey sand, 12 to 36 inches.	.3	3.7	16.7	49.9	6.8	8.5	14.2

NORFOLK LOAM.

The surface soil of the Norfolk loam consists of a gray fine to very fine sand and silt, containing considerable organic matter and having a depth of 8 to 10 inches. The relatively high percentage of very fine sand and silt is very noticeable in the field, giving the soil a mealy, velvety texture. In addition to the typical areas of this soil there are a few spots scattered here and there which are more nearly a clay loam. These places, however, occur in such a way that they could not be separated from the fine sandy loam under existing conditions. There are also a few areas where the soil is yellow fine sand to a depth of 36 inches or more, but these were too small to be shown as a separate type on a map of the scale used.

The subsoil of the Norfolk loam to a depth of 36 inches is a yellowish to grayish fine to very fine sand and silt. In a few places the fine sandy loam grades into a mottled, sticky, sandy clay at from 24 to 30 inches, and the clay loam areas of the soil are underlain by a dark clay or loam.

The Norfolk loam occurs in large unbroken areas of very irregular outline along Red, Little Biloxi, Big Biloxi, and Wolf rivers, and to the west of Landon. Many smaller areas and narrow strips are found elsewhere throughout the area surveyed, especially near the bayous and the depressed places in the Norfolk fine sandy loam.

The surface features of this type are very uniform throughout, as it occupies the low, level areas between the Norfolk fine sand and the rolling uplands and the extended areas of flat land along the stream courses. In a few instances it is found as second bottom land or terraces, lying a few hundred yards from the more recent bottom lands. The elevation of this type above tide water varies considerably. At the mouths of the rivers and to the west of Landon it rises only a few feet above sea level, while farther north it reaches an altitude of 180 feet above tide water.

Part of this type has fairly good natural surface drainage, but the more level areas west of Landon and near the bayous are so flat in many places that the surface water runs off very slowly. Such areas would be greatly benefited by open-ditch or tile drains. The areas lying along the Big and Little Biloxi and Red rivers are fairly well drained, as the country gradually slopes southward. The streams have cut deep, wide channels, and small open furrows would be sufficient to carry off the surplus rain water. This land is overflowed only during unusually heavy rains.

The Norfolk loam is largely of alluvial origin. The streams having their headwaters in the areas of Norfolk sand and Norfolk fine sandy loam have brought down considerable quantities of fine sand and silt and deposited this material during periods of flood waters. The dark-gray and blackish color of this soil is due to the organic matter laid down in the floods or added by decaying vegetation. The heavier phases probably owe their origin to the fact that in the bends of the rivers the backwater from the slow-moving currents has deposited a greater amount of clay and silt than was deposited in the swifter flowing currents on the opposite side of the stream.

As yet none of the Norfolk loam is under cultivation. It is covered for the most part with pine, gum, cypress, oak, and magnolia, and some other hardwoods. The greater part of this type can be cleared and made ready for cultivation at a nominal expense, although not quite so cheaply as some of the upland soils. While no crop yields can be given, it is safe to say that this soil is naturally one of the most productive in the area surveyed. It could be very easily tilled, and also possesses favorable moisture conditions. Judging from its texture and its use in other areas, this type will produce good corn, oats, grass, sugar cane, cabbage, watermelons, cucumbers, and late truck.

The analyses of the following samples give the texture of the Norfolk loam:

Mechanical analyses of Norfolk loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10883	4 miles W. of Wiggins.	Gray fine sandy loam, 0 to 9 inches.	0.1	0.9	1.6	28.4	35.1	26.9	7.0
10885	1 mile NE. of Wortham.	Gray fine sandy loam, 0 to 9 inches.	.2	.4	.3	9.7	32.9	46.5	9.7
10884	Subsoil of 10883	Yellow fine sandy loam, 9 to 36 inches.	.1	.6	4.4	24.7	29.8	27.5	12.7
10886	Subsoil of 10885	Silty and fine sandy loam, 9 to 36 inches.	.1	.2	.2	7.6	28.8	48.0	15.6

ORANGEBURG FINE SANDY LOAM.

The Orangeburg fine sandy loam, locally spoken of as the "big level land," consists of a brownish heavy sandy loam of rather fine texture to a depth of 8 inches. The subsoil, from 8 to 36 inches, varies from a red loam to a friable sandy clay of reddish color containing quite a high percentage of fine sand particles. It occasionally happens that the red sandy clay grades into a reddish sticky sand at 30 inches. There are a few spots of this type where the soil acts like a loam and others where the surface material is quite sandy. The type as a whole contains a slightly greater amount of organic matter than the other upland soils, and also more than is usually found in this type of soil in other areas.

The development of the Orangeburg fine sandy loam in the present survey is very limited. The two main bodies are found in the vicinity of Wisdom and about 2 miles north of that place, while a few small scattered spots occur in the northern part of the area.

The surface features of the Orangeburg fine sandy loam are very uniform throughout. It occupies broad, level, and gently rolling areas, which have an average elevation of about 200 feet above tide water. It lies somewhat higher than the immediately surrounding soil types and covers the flat top of the interstream area of country lying beween Flint Creek and the tributaries of Black Creek, just east of the present survey.

This type, although level or gently rolling, has good natural surface drainage, a feature due to its elevated position and the friable character of the subsoil. Any of the more level areas can be easily drained by means of open ditches.

The Orangeburg fine sandy loam is probably derived from the weathering of the red sandy clays of the Lafayette formation.

A few farms on the Orangeburg fine sandy loam have been in operation since the interior of the country was settled. Proportionally more of this type is under cultivation than of any other soil in the area, although the greater part of it has been covered until recently with an excellent growth of longleaf pine. This timber is rapidly being cut.

Some of the best farms in the northern part of the county are located on the Orangeburg fine sandy loam, and this section is more of an agricultural community than any other part of the interior of the county. This soil is recognized as the most productive of the upland types. Corn, oats, cotton, sugar cane, potatoes, garden vegetables, peaches, and small fruits are successfully grown. Sugar cane does well for one or two years, but after that time only a moderate yield can be secured without heavy applications of manure. Cotton does fairly well, averaging from one-half to two-thirds of a bale per acre. This type seems to be a good soil for peaches, small fruits, pecans, figs, and berries, and also for pears, but the pears blight within a few years. For general farming purposes the Orangeburg fine sandy loam is the best of the upland soils.

Below are given the mechanical analyses of samples of the Orangeburg fine sandy loam:

Mechanical analyses of Orangeburg fine sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10629	¼ mile N. of Wisdom.	Brown fine sandy loam, 0 to 8 inches.	0.1	3.7	10.5	31.6	13.2	26.2	14.7
10631	3 miles N. of Wisdom	Brown fine sandy loam, 0 to 8 inches.	.4	5.4	11.6	25.2	12.1	29.6	15.6
10630	Subsoil of 10629	Red heavy loam, 8 to 36 inches	.2	2.5	7.7	28.9	11.0	23.3	26.4
10632	Subsoil of 10631	Red clay, 8 to 36 inches...	.3	3.9	9.0	20.9	9.0	25.3	31.5

MEADOW.

The areas mapped as Meadow in this survey consist of low, flat, wet land occurring at the heads of bayous and along the rivers and small streams. The soil varies from a silty loam to a fine sandy loam containing quite a high percentage of organic matter. The subsoil is usually somewhat heavier in texture than the soil, though frequently it is a fine sand or sandy loam. There are two phases of this Meadow soil. One is the marsh land at the mouth of the Wolf River, on the Bay of Portage, and at the head of Back Bay; the other is composed of the narrow strips found along the small streams.

The largest bodies of Meadow occur in the vicinity of Delisle and near the Bay of Portage, with similar and smaller areas at the head of Back Bay; while the largest areas found along the small streams lie north of the Wolf River and in the neighborhood of Nugent.

This soil occupies the lowest position of any type in the area. The marsh areas of it are only from 1 to 3 feet above tide water, and are inundated during storms on the coast. The narrow strips are flat, but not so uniformly level as the marsh areas. It is impossible to drain the latter on account of their low elevation above tide water, but the small bodies of this type throughout the interior of the county can be easily drained by means of open ditches or by opening and enlarging the present channels of the streams.

The Meadow owes its origin to the deposition of sediment during high waters and to the wash from the adjoining uplands. Frequently leaves, pine straw, and branches of trees are caught and buried in this wash along the streams, and their decay has in some places charged the soil heavily with organic matter.

As yet none of the Meadow is under cultivation. The marsh areas are covered with a dense growth of water-loving grasses, characteristic of salty conditions. The narrow strips along the small streams are forested to gum, cypress, poplar, oak, and other hardwoods, which as yet are of little commercial use. If these strips were cleared and cultivated it is believed they would prove to be by far the most productive lands in the area, as they are made up of heavy-textured soil, containing considerable organic matter, and possessing a moisture supply sufficient to resist droughts. Corn, oats, sugar cane, and grasses would do well on this Meadow land. It would also make excellent pasture.

On account of the wet nature of this type no samples were collected.

AGRICULTURAL CONDITIONS.

Although Harrison County was settled nearly two hundred years ago, but little attention has been given to the advancement of agricultural interests, and as a consequence the area is but sparsely inhabited. Until recently it was one vast forest of longleaf pine, and at present lumbering, turpentine distilling, and charcoal burning are the important industries throughout the interior of the area surveyed, while the catching of fish and oysters is the chief pursuit of those living along the coast. During the last two years the trucking industry along the Louisville and Nashville Railroad and to the north of Longbeach has acquired some little importance.

The farming class in the Biloxi area have not made great progress in the agricultural development of their country, and have given their attention largely to raising hogs and other live stock on the open range, while drawing an income from the valuable forests of pine that covered so large a part of the county. Many, settling here and there in the pines, obtained the land from the Government at a small cost, and the returns from the sale of timber—all clear profit—and from turpentine and charcoal have provided an easy living. Occasionally a good farmhouse is seen, neatly painted and fenced in, and near this usually a fairly good barn for a warm climate. The majority of the farmhouses, however, are small frame or log houses with from one to three rooms and with a chimney built of mud held together by sticks. Such places seldom have barns worthy of the name. Along the coast the farm buildings are better, and the surroundings show considerably more thrift and activity than farther in the interior.

The small amount of cleared land is tilled chiefly by the owners themselves. Occasionally the land is rented, and in such cases the tenant pays a certain part of the crop produced. There are only a few places in the area where the land is properly cultivated, the best example being seen on the truck farm north of Longbeach, which is operated by a firm—the pioneers in commercial truck growing in the area.

The farms in the southern part of the county vary in size from a few up to 100 acres, while those of the interior probably average about 160 acres. The average size of farms for the whole county, according to the Twelfth Census, is about 125 acres. It must be understood, however, that less than one-seventh of the county is included in farms, the remainder being held in large tracts by lumbering corporations. A conservative estimate of the proportion of land under cultivation in the area surveyed would probably place it at less than 5 per cent, exclusive of gardens immediately surrounding the houses. A farm of 160 acres in most instances will not have more than one small patch or field under cultivation, and in many sections in the interior of the area no farming whatever is carried on.

Throughout the southern part of Mississippi, and especially along the coast, labor for farm work is very scarce. Most of the field work is performed by the owners of the land and their immediate families. The lumber and fishing interests can afford to pay higher wages than the farmers, and these lines of industry absorb the greater proportion of the available labor. The negroes prefer to work around the sawmills, turpentine stills, and docks rather than in the fields. Wages for all grades of farm work are rather high, and the laboring man can easily make a living.

As before mentioned, lumbering, turpentine distilling, charcoal burning, and the catching of fish and oysters are the chief industries of the area. The greater part of the farming is done in the coast section of the county, and here the trucking industry assumes its greatest proportions. Such crops as lettuce, radishes, cucumbers, beets, cabbages, beans, potatoes, sweet potatoes, watermelons, and cantaloupes are most successfully grown. Figs of the Celeste and Black varieties and pecans are grown to a considerable extent along the coast and to a limited extent in the northern part of the area. Corn, oats, cotton, sugar cane, garden vegetables, and peaches are raised chiefly on the uplands. Plums do well, and pears also, except for their early blighting. Quite a number of cattle and sheep are raised, these running at large on the range the entire year. Spring lambs can be put on the market very early in the season. Much wool is produced annually. Peach growing is in its infancy, but promises to be one of the important industries of this section. Poultry raising and dairying would also be paying industries, as local prices for these products are very high throughout the year.

To recapitulate the salient crop values of the soil types of the Biloxi area, the Norfolk fine sand is undoubtedly the best for early truck. Pecans and figs are also well adapted to it. The moisture conditions in some places are quite favorable, and lying, as it does, along the railroad, the facilities for shipping truck to the northern markets are very good.

The Norfolk loam would probably be one of the most productive soils in the area surveyed, but as yet none of it is under cultivation. Its surface conditions would permit it to be cultivated with machinery. This soil would produce fairly good yields of corn, oats, cotton, grasses, and sugar cane.

The Norfolk fine sandy loam is farmed to corn, oats, cotton, sugar cane, and garden vegetables. A few peaches, pecans, and figs are also grown. The clayey subsoil of this type makes the effect of manuring more lasting than on any other soil type in the area; the same characteristic improves the type as regards moisture supply in dry periods.

The Norfolk sand, owing to its texture and free drainage, is a warm, early soil, and one which, with heavy applications of manure and abundant rainfall, will produce fairly good yields of truck and berries. It suffers seriously from drought, even during ordinarily dry seasons, and is not suited to general farming purposes.

The Orangeburg fine sandy loam, locally known as the "Big Level," is the best general farming land in the area surveyed, and was so recognized by the early settlers of the county. It produces fairly good yields of cotton, oats, corn, sugar cane, garden vegetables, and fruits.

As a rule, the soils of the area are deficient in organic matter. Large quantities of pine needles could easily be obtained as litter for the stables and barnyards, and these would not only act as an absorbent, but in their decay would add considerably to the humus content of the soil. Even the pine straw alone would be of some value to the soils. Leguminous crops, such as clover and cowpeas, if plowed under, would add nitrogen to the soil. Both the texture and moisture conditions of these sandy soils could be easily improved to a certain extent by the above methods. By a special arrangement of the Louisville and Nashville Railroad Company a considerable quantity of stable manure is shipped in car lots from New Orleans to the truck growers along the coast. This manure can be secured at the nominal rate of $10 a car delivered.

The area surveyed is very well situated as regards transportation facilities. The main line of the Louisville and Nashville Railroad crosses the southern portion of the county. Freight schedules average forty-five and fifty-six hours to Cincinnati and Pittsburg, respectively. Ventilated and refrigerator cars are used for shipping the truck. Lettuce, radishes, beets, cabbages, onions, etc., in carload lots, can be shipped to these places, for instance, at a cost of from $70 to $115 a car. The Gulf and Ship Island Railroad runs north from Gulfport through the area surveyed. This road handles the lumber from the interior.

The dirt roads of the area are in poor condition, but are probably as good as can be expected in a new, undeveloped country. They are seldom worked, and run in almost any direction, dodging around pines and gullied places. The streams in the interior of the county are bridged here and there, but the bayous and rivers in the southern part are crossed by means of ferries, and the ferriage charges are high. Cheaper rates and more bridges owned by the county would do much to attract settlers to the area.

While there are no large cities in the area surveyed, Biloxi, Gulfport, Pass Christian, McHenry, and Wiggins offer excellent markets for part of the products of the area. The greater part of the truck is sent to Louisville, Cincinnati, Pittsburg, and other northern points. About 50 carloads of truck were shipped from the area during the spring of 1904. Shipments of these products will probably increase rapidly from this time on, as the trucking industry is only in its infancy. Gulfport has quite a good harbor, and many ocean steamers enter that port. Millions of feet of lumber are exported annually, and the town is developing rapidly. There is a canning factory for fruits and tomatoes at Wiggins and also one at Perkinston. The only cotton gin in the area is located at Wiggins. About 30 bales of cotton were handled there during the last season. Quantities of fish and oysters are each year shipped from Biloxi and Pass Christian.

Speaking generally, the future agricultural development of the Biloxi area lies in the production of early truck—for northern shipment—small fruits, peaches, figs, and pecans.

SOIL SURVEY OF DE SOTO PARISH, LOUISIANA.

By GROVE B. JONES and LA MOTT RUHLEN.

LOCATION AND BOUNDARIES OF THE AREA.

De Soto Parish is situated in the northwestern part of the State of Louisiana. It is bounded on the north by Caddo Parish, on the east by Natchitoches and Red River parishes, on the south by Sabine Parish, and on the west by the State of Texas. The parish comprises an area of about 825 square miles and has a population of about 25,000. The colored population is more than twice as great as the white.

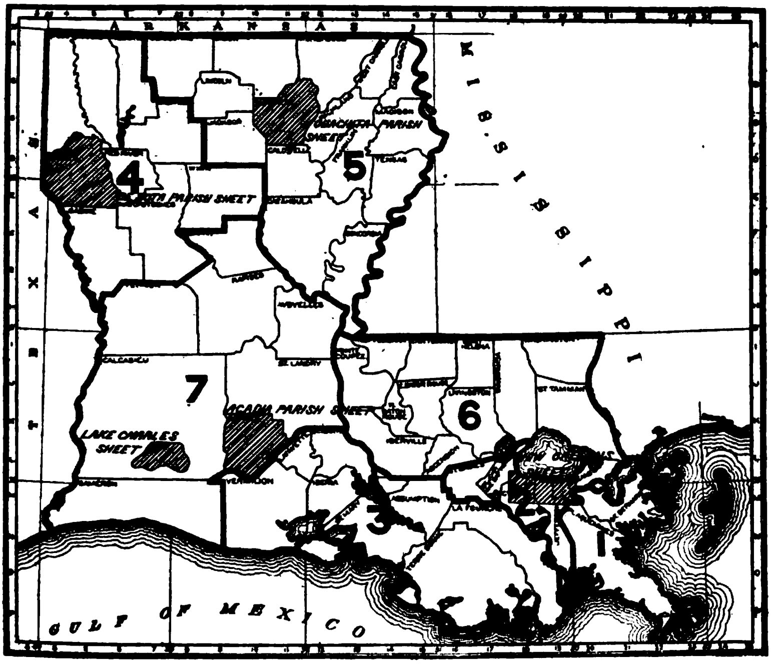

FIG. 15.—Sketch map showing location of the De Soto Parish area, Louisiana.

Mansfield, the principal town of the area, is the parish seat. It has a population of nearly 2,000 and is situated near the center of the parish. Logansport, on the Sabine River, Grand Cane, in the north central, and Keatchie, in the northwestern part of the parish, rank next in size and importance.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

De Soto Parish was organized in 1843, with the parish seat at Mansfield. The first permanent settlements had been made some half century earlier, and the population had grown especially fast after the admission of Louisiana as a State. A number of squatters located in this region purchased their holdings of the Government at a nominal price, while some lands were taken up under the homestead entry laws. During the decade 1830–1840 a large number of immigrants came from North and South Carolina, Georgia, and Alabama, and when the parish was established each Congressional township had its full complement of resident landowners.

The early settlers took up lands in the higher sandy parts of the parish, where they found an abundance of timber for fuel and building purposes. The alluvial bottom lands remained in their natural state until comparatively recent years.

Grain, chiefly corn, was the one crop interest during the early development of De Soto Parish, and cattle raising was of probably equal importance. Cotton was introduced later, and its production has steadily increased until it is now the staple crop.

In the early days a little tobacco, solely for home use, was grown, but it is not now a product of the area, although it would seem that the soil and climate were suitable for growing a good type of cigar wrapper or filler. Sugar cane for manufacture of the home supply has also formed one of the products of this area.

As will appear from this report, there is a wide range in the soils of the parish, and although up to the present time there has not been much variety in the crops grown, there is every reason to believe that with growth of population and the resulting greater intensiveness of agricultural practice many special crops will be produced. Already there is some indication of this change in the more thriving parts of the parish.

CLIMATE.

The normal temperature and precipitation of De Soto Parish are given in the appended table, compiled from Weather Bureau records. From its examination a general idea of the climatic conditions of the area may be had.

Mansfield is situated in the central part of the parish, and Oxford in the southern part, while Shreveport lies about 30 miles north of Mansfield, in Caddo Parish.

Normal monthly and annual temperature and precipitation.

Month.	Mansfield.		Oxford.		Shreveport.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	°F.	*Inches.*	*°F.*	*Inches.*	*°F.*	*Inches.*
January	42.4	1.50	46.6	5.37	46.3	4.75
February	44.0	3.67	45.8	3.92	50.9	3.88
March	56.3	6.22	58.0	5.33	58.3	4.57
April	66.1	3.26	65.7	4.21	66.7	4.85
May	73.9	2.79	71.6	3.88	73.8	3.97
June	79.1	4.85	80.2	3.84	80.5	3.82
July	82.0	2.58	81.2	2.70	83.3	3.29
August	82.0	1.65	81.2	2.87	82.3	2.13
September	76.6	2.85	76.4	1.74	76.5	3.56
October	....	4.32	64.1	3.30	66.2	3.22
November	55.7	6.10	55.2	4.12	55.4	4.37
December	47.0	4.39	47.8	3.40	49.7	4.37
Year	....	44.18	64.4	44.68	65.8	46.78

PHYSIOGRAPHY AND GEOLOGY.

The idea is quite common abroad that the State of Louisiana, embracing a little more than 45,000 square miles, is all alluvial, or a low-lying swamp. Such is not the case, as more than half its area may be classed as uplands, with soils of varying character. De Soto Parish is known as one of the "hill" parishes of north Louisiana. It has an undulating surface of hammock, hill, and valley. The elevation at Mansfield is about 375 feet above sea level, and is probably the highest in the State.

The southeastern part of the parish constitutes the most uneven and broken section of the entire area. It is gullied and ridged by scores of small streams which have their origin in springs in the hills. The erosion of these small streams has in some places imparted to the hills an abrupt, choppy contour. Some parts are even rugged. The greater part of this broken country is known as the "Dolet Hills."

The parish as a whole is well drained, being intersected by numerous small branches and bayous. There are, however, some low areas which have no well-developed stream courses, and where the drainage is consequently poor and the land "crawfishy." Sand mounds of varying size are a characteristic feature of the topography, and are quite generally distributed.

Nearly all the streams have their sources within the boundaries of the parish, and in a general way it may be said that the Texas and Pacific Railroad follows the drainage divide between the Red River and Sabine River systems. Streams on the east side eventually reach the Red River through Bayou Pierre River and its tributaries, while those to the west empty into the Sabine. There are a number of bayous of some importance, but these are sluggish and are practically dry during the greater part of the year. In the southern part of the area are Bayou San Patrice and Cow Bayou, while Bayou Lavacheria and Bayou La Bonchasse drain the north-central part and empty into Bayou Pierre Lake. Keatchie and Cypress bayous form the northern boundary of the parish until the latter stream reaches Wallace Lake. But little of the drainage water of De Soto Parish finds its way into either of these streams. Castor Bayou, which heads near Keatchie and extends nearly across the parish, together with Grand Cannes Bayou, drains the western section. These two bayous unite near the Sabine River, and empty into it about 3 miles below Logansport.

It is characteristic of the bayous to have narrow, tortuous channels with only a slight fall, and new channels are being continually cut through their level flood plains. These streams are sluggish, are obstructed by driftwood and material washed down from the hills, and consequently overflow their banks during heavy rains.

The stream bottoms are wide, being cut by numerous abandoned channels which serve as outlets or cut-offs only in times of high water. The soils of these bottoms are wash material, and vary from a sandy loam near the uplands to a silty loam or clay in the wet areas.

Bayou Pierre River formerly flowed out of the Red River north of the De Soto Parish line, and emptied into the same river southeast of the parish. In the same way Red Bayou flowed out of Bayou Pierre River and back into it again. The formation of these cut-offs was caused by the obstructed channel of the Red River. For many miles this channel was choked up by undermined trees, logs, stumps, sandbars, etc., thus forming what was known as "the Red River raft." This obstruction impeded the flow of the current, causing new channels to be formed. By backing the water up into the valleys of the tributaries numerous lakes were formed.

A few years after the first Government survey, which was made about 1820, the raft was removed, but later formed again. It was not until 1872–73 that the Government successfully removed this obstruction, and thereby entirely changed the drainage system of this section of the country. A levee was built along the west bank of the Red River, which closed the openings where Bayou Pierre and other streams started, so that at present no water from the Red River enters the former stream.

The numerous lakes formed during the "raft period" have gradually been drained, and areas that fifteen or twenty years ago were submerged are at present under cultivation. This is true of the greater part of Wallace, Cannisnia, and Bayou Pierre lakes. Through these former lake beds run shallow channels, in which the water is confined except in times of flood. This change in drainage has placed the parish boundary line in dispute, as it is not certainly known what constitutes the "lake." This plane-table survey was made along the boundary lines as established in 1843–1845.

The lake soils are capable of being improved by drainage, and will prove valuable for general farming. Their texture and character depend upon the rate at which they were deposited, which conditions are fully described later in the report.

Springs occur throughout the area, being especially numerous in the rougher sections. Wells whose waters possess curative powers also abound.

As this parish is situated in the Coastal Plain, all of the strata from which the soils have been formed are of Eocene or later age. According to Harris and Veatch,[a] the material forming the upland part of the parish belongs to the lignitic stage of the Eocene. Lignite outcrops occur both in the Dolet Hills and along the Sabine River, while well borings show the presence of this formation underlying the entire parish. Recent experiments have shown this lignite to be of little value for fuel. The deeper strata may, perhaps, prove to be a more mature product, worthy of development. The Pleistocene is represented by at least two divisions. The older of these, from which the Lake Charles fine sandy loam has been formed, probably belongs to the Port Hudson stage, while the later comprises the recent alluvial deposit along the streams.

SOILS.

Ten distinct soil types were recognized and mapped in this area. The following table shows the actual and relative extent of each type:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Norfolk fine sandy loam	244,992	46.4	Miller clay	9,152	1.7
Susquehanna fine sandy loam	110,336	20.9	Orangeburg fine sandy loam	6,976	1.3
Meadow	72,448	13.7	Miller silt loam	5,248	1.0
Lake Charles fine sandy loam	62,592	11.9	Swamp	2,048	.4
Susquehanna clay loam	14,080	2.7	Orangeburg sandy loam	192	.0
			Total	528,064	

NORFOLK FINE SANDY LOAM.

The surface soil of the Norfolk fine sandy loam is a gray to grayish-brown loamy fine sand, or light fine sandy loam. In depth it varies from 12 inches to 3 feet or more, with an average depth of about 18 inches. Some areas of this soil contain a small percentage of iron concretions, while on the abrupt slopes as much as 25 per cent of iron concretions and ferruginous sandstone frequently occurs.

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[a] Geological Survey of Louisiana, 1899.

The subsoil usually contains a high percentage of sand, and consists of a yellow, sticky, fine sandy loam grading into a yellow or yellowish-red loam or sandy clay. The subsoil is often mottled yellow, white, and gray streaked with red, and presents a beautiful marbled appearance when thus exposed.

The Norfolk fine sandy loam is the most extensive type of De Soto Parish, and is generally distributed throughout the area. It occupies gently rolling to hilly uplands, and occurs in rather flat, moundy areas near streams. In the vicinity of Oxford this soil is typically developed, and occurs in an unbroken area. Generally speaking, however, the Norfolk fine sandy loam is interrupted by many areas of other soils. While a rolling topography characterizes the greater part of this soil, the surface features vary considerably. In the eastern and southeastern parts of the area this type is found occupying a rather hilly position, and the soil is somewhat looser in texture and the sands coarser. On the tops of these elevations the soil may be a loose sand to a depth of 3 feet or more. Along the Sabine River northwest of Logansport the same condition exists. In this vicinity there is a sprinkling of waterworn quartz pebbles, usually less than 1 inch in diameter. The distribution of this material is irregular, and covers but limited areas.

Where the Norfolk fine sandy loam borders on the Lake Charles fine sandy loam the sand particles are finer, and this may be said to be true of the sands of the entire northern part of the parish. Again, as we approach the streams, the surface is marked by low sand mounds, and the soil is slightly more compact. These moundy areas are inclined to be wet during rainy seasons, but only in a few cases will artificial drainage be found necessary.

The Norfolk fine sandy loam is believed to have a two-fold origin. Where the type is characterized by topography imparting to the hills a rather sharp contour, and where the elevations are high but the slopes are not steep, the soil has been formed directly from the underlying sandy clays, which probably belong to the lignitic stage of the Eocene age. Where the type occurs in level or gently rolling areas, the soil appears to be the result of a water deposit reworked with the transported weathered material of the higher elevations. This reworking of the upland product with the valley material has undoubtedly taken place many times, evidence of the sorting power of water appearing in the different texture and depth of the soil.

There is a larger proportion of this type under cultivation than of any other upland type. It is easily cultivated, has good drainage, and responds readily to fertilization. The principal crops grown are cotton and corn, with an occasional field of oats. For cotton the average yield is one-third bale to the acre where not fertilized. When 200 pounds of fertilizer are used to the acre a bale per acre is not an uncommon yield. Corn yields from 10 to 20 bushels per acre. While the grain yield of oats is light, the hay makes an excellent winter roughage. Peanuts, sorghum, ribbon cane, and sweet and Irish potatoes are grown for home consumption.

With the practice of clean cultivation given corn and cotton this sandy soil soon becomes deficient in organic matter. A rotation of crops, including cotton for two years and corn one year, followed by cowpeas, would be very beneficial. The soil is said to be deficient in phosphoric acid. It also needs liberal applications of humus to aid in conserving moisture. Through systematic farming and careful management a few farms on the Norfolk fine sandy loam have been brought to a higher state of productiveness than the virgin soil.

Crops requiring a heavy, strong soil are not grown on this type, but any crop adapted to a light, sandy soil does well. The soil is well adapted to early truck and fruit crops, and these industries, established on a systematic basis, could be made profitable. Crab, Bermuda, and carpet grass afford good pasturage and hay.

The timber growth consists of shortleaf pine, sweet gum, ash, hickory, beech, and many varieties of oaks.

The following table gives the results of mechanical analyses of the fine earth of the soil and subsoil of this type:

Mechanical analyses of Norfolk fine sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11907	Spider	Fine loamy sand, 0 to 18 inches.	0.2	0.5	1.2	42.1	32.0	18.9	4.9
11905	3 miles NE. of Stonewall.	Light fine sandy loam, 0 to 20 inches.	.6	.8	2.8	46.6	24.0	19.4	6.6
10810	1 mile N. of Benson	Light fine sandy loam, 0 to 18 inches.	.2	.3	.8	41.4	23.6	25.8	8.1
11906	Subsoil of 11905	Fine sandy loam, 20 to 36 inches.	.6	1.0	2.2	34.3	20.1	23.2	18.7
11908	Subsoil of 11907	Yellow fine sandy loam, 18 to 36 inches.	.3	.3	.9	32.3	23.8	23.5	19.0
10811	Subsoil of 10810	Fine sandy clay, 18 to 36 inches.	Tr.	.3	.6	28.5	18.4	23.8	28.2

SUSQUEHANNA CLAY LOAM.

The soil of the Susquehanna clay loam is a brown or gray sandy loam with a maximum depth of 8 inches, but varying considerably below this figure. It is composed of fine sands and silt, but varies somewhat in texture and may range in places to a loam or clay loam. There are usually present on the surface and mixed through the soil many iron concretions and impure sandstone fragments. This is especially true where the type is found occupying the high ridges and hills where the contour is abrupt. In some places silicified wood fragments are thickly scattered upon the surface.

The subsoil consists of a red or reddish-yellow clay, which usually contains sufficient sand and silt to make it friable. Where the more plastic clay occurs the surface soil is usually very shallow and may be entirely absent. The subsoil contains iron concretions and fragments of ferruginous sandstone, and may become quite sandy and friable at about 3 feet. There is no well-defined boundary between this soil and the Susquehanna fine sandy loam.

The surface characteristics of this soil vary considerably. With the exception of the fairly level areas bordering the lakes and streams in the northern and eastern parts of the parish, the Susquehanna clay loam occupies rolling areas. In some parts of the parish the erosion of the numerous small streams has imparted to this type a somewhat rougher surface.

The Susquehanna clay loam probably owes its origin to the weathering in place of the underlying clays. The rolling areas are well drained, while the level areas would be greatly benefited by open drains or underground tile. Being adjacent to streams. these areas could be drained at little expense.

Little of this type of soil has ever been under cultivation. For general farm products it is believed to be one of the best soils in the area, but it is difficult to cultivate and has been neglected for this reason. Some cotton and corn are grown upon it, giving fair yields. It is a strong grass soil and is well adapted to all crops requiring a heavy, strong soil. Peaches can be profitably grown upon the well-drained areas. Most of the type is at present covered with forests of oak, hickory, ash, and sweet gum.

The following table shows the results of mechanical analyses of typical samples of the Susquehanna clay loam:

Mechanical analyses of Susquehanna clay loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11915	4 miles NW. of Frierson.	Loam, 0 to 6 inches	3.9	3.3	0.7	4.8	28.0	47.0	12.0
10814	2 miles S. of Pelican.	Very fine sandy loam, 0 to 4 inches.	.4	1.1	.6	12.5	41.6	30.5	13.2
10815	Subsoil of 10814	Red clay, 4 to 36 inches	.1	.3	.1	3.5	23.2	22.4	50.3
11916	Subsoil of 11915	Clay, 6 to 36 inches	.2	.4	.1	.7	9.1	29.3	60.1

SUSQUEHANNA FINE SANDY LOAM.

The Susquehanna fine sandy loam is distributed throughout the parish in areas of varying size. The most extensive areas occur in the eastern and southeastern parts of the survey.

The surface soil consists of a grayish fine sand or light fine sandy loam from 10 to 20 inches deep. The subsoil is a red or yellowish-red sandy clay or loam, which often with greater depth grades into a friable sandy material, but in the main the material is not nearly so porous as the Norfolk fine sandy loam subsoil, and it often becomes a stiff, plastic clay containing but a small percentage of sand. The type differs from the Norfolk fine sandy loam also, in that there is no gradual change from soil to subsoil, but the sandy covering is usually found resting directly upon the red clay foundation. Iron concretions are usually present in both soil and subsoil in varying amounts. The hilly areas are often quite stony on the slopes, while silicified wood fragments are not infrequent.

There is little or no uniformity or regularity of occurrence to this type. Small isolated areas, usually at a slight elevation above the surrounding country, occur within the Norfolk fine sandy loam. These are often too insignificant to map. The type, however, is generally characterized by a rolling topography, while in some sections the contour of the hills is abrupt. Owing to the loose character of the soil and the physiographic position it occupies, there is considerable variation in depth and texture. Two elevations in close proximity to each other and of the same height present entirely different features. The surface soil on one of these hills may be an incoherent sand having a depth of 24 inches, while on the adjacent hill the subsoil may be exposed. A sandy covering of varying depths may occur on one slope, while the opposite side may be void of a covering. This unequal erosion is less pronounced where the contour of the hills is rounded, and here the soil is comparatively uniform. When the rougher sections of the Susquehanna fine sandy loam are cleared and the soil broken up, washing takes place rapidly and the sandy covering is soon removed.

Like the Norfolk fine sandy loam, at least part of this soil has been derived from the underlying clays, while a great deal is reworked material.

The Susquehanna fine sandy loam is well drained for the most part, there being only a few small areas where artificial drainage would be required. The type, as a whole, is considered a stronger soil than the Norfolk fine sandy loam, and cotton, corn, and cowpeas are grown with perhaps a slightly higher average yield than upon the soil last mentioned. The Susquehanna fine sandy loam is also well adapted to the growth of fruit and vegetables, and potatoes do exceptionally well. Some remarkably good results have been obtained from the many young peach orchards, the soil being admirably adapted to this fruit. The timber growth consists of both hard and soft woods, the former predominating.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Susquehanna fine sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11901	2 miles S. of Cook	Gray fine sand, 0 to 12 inches.	0.2	0.7	0.4	33.6	43.6	16.2	5.2
10812	2 miles W. of Evelyn.	White fine sand, 0 to 15 inches.	.3	.7	.4	46.6	32.4	12.8	6.9
10308	2¼ miles W. of Pelican.	Gray fine sand, 0 to 15 inches.	.6	.4	1.0	44.6	31.4	12.9	8.9
11902	Subsoil of 11901	Red clay, 12 to 36 inches.	.4	1.0	.5	6.9	17.5	35.1	38.7
10309	Subsoil of 10308	Red sandy clay, 15 to 36 inches.	.2	.1	.3	23.5	20.6	11.6	42.7
10813	Subsoil of 10812	Red clay, 15 to 36 inches.	.1	.1	.1	10.7	22.1	13.9	53.0

LAKE CHARLES FINE SANDY LOAM.

The surface soil of the Lake Charles fine sandy loam is a light-gray or grayish-yellow compact fine sandy to silty loam, varying in depth from 6 to 14 inches, and often containing decomposed iron concretions, which stain it a dark-brown color. The subsoil is a yellow, fine sandy to silty loam, grading into mottled yellow and gray clays, often streaked with red. These clays contain an admixture of from 20 to 30 per cent of very fine sand and from 40 to 50 per cent of silt.

This type of soil is found distributed over the entire parish, but usually in areas of limited extent. The largest and most typically developed bodies are found in the northeastern part of the parish, where a neck of land known as "The Point," which extends in a southeasterly direction between Cannisnia Lake and Bayou Pierre Lake, embraces about 15 square miles of this soil.

The Lake Charles fine sandy loam, although 30 or 40 feet above the adjacent drainage systems, has no well developed stream valleys. The water finds no outlet, and is left to evaporate from the little swamps which form between the small mounds or hummocks with which the surface is almost always covered. These mounds vary in height and size, the average elevation being about 4 feet. They are made up of a moderately productive sandy loam or sand, while the intermound spaces consist of a light-gray silt loam underlain by a stiff, ash-colored clay containing a high percentage of silt. This poorly drained intermound soil is known as "post-oak clay," and the areas embraced by it are known as "post-oak" or "pin-oak flats," depending entirely upon the nature of the timber growth.

The Lake Charles fine sandy loam is believed to be largely derived from the geological formation known as the Port Hudson deposits.

Owing to its peculiar topography the type is naturally wet, and yet its structure is such as to make it very susceptible to drought. During wet seasons crops on the intermound spaces are drowned out, while in droughty times the sand mounds suffer. A very small proportion of this soil is under cultivation, and the yields are only fair. After one or two years the natural productivity of the soil rapidly decreases, nor does the application of fertilizers prove of lasting effect, as the plant food soon leaches out. The soil is also naturally deficient in organic matter, and altogether requires careful treatment. With proper drainage and the liberal application of barnyard manure, together with the growing of legumes, this soil could be made productive.

When fertilized the soil produces abundant yields of sugar cane, but cotton and corn do not readily respond to the stimulus, there being no appreciable increase shown in the yields. If properly drained and fertilized it is believed this would be a good truck soil, and one especially adapted to the growing of strawberries. It also produces a good growth of grass, and should be sown to some native grass, as Bermuda or crab grass. At present the greater part of the type is undoubtedly better adapted to stock raising than to the growing of crops.

The value of land composed of the Lake Charles fine sandy loam ranges from $3 to $7 an acre.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Lake Charles fine sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10812	8 miles N. of Benson.	Gray silty and fine sandy loam, 0 to 8 inches.	0.3	0.3	0.4	11.9	32.7	43.1	10.8
11909	1 mile NW. of Stonewall.	Gray silty and fine sandy loam, 0 to 9 inches.	2.1	3.3	.8	14.9	22.5	42.9	13.2
11911	8 miles SE. of Frierson.	Loam, 0 to 8 inches	.4	.2	.2	4.6	26.6	43.7	24.3
11912	Subsoil of 11911	Loam, 8 to 36 inches	.2	.7	.3	6.8	27.4	51.3	13.0
10813	Subsoil of 10812	Clay loam, 8 to 36 inches.	.2	.3	.2	9.0	25.2	37.6	26.9
11910	Subsoil of 11909	Loam to silty clay, 9 to 36 inches.	1.1	1.7	.5	9.2	19.5	40.2	27.4

ORANGEBURG FINE SANDY LOAM.

The soil of the Orangeburg fine sandy loam is a red, fine sandy loam containing a large proportion of fine sand and silt. It ranges in depth from 10 to 15 inches and contains many iron concretions and ferruginous sandstone fragments, which may amount to as much as 40 per cent of the entire soil mass.

The subsoil consists of a heavy red sandy clay with a depth of 3 feet or more. There is usually present in the subsoil sufficient sand to cause it to become friable, though in some areas the material is plastic and somewhat tenacious. As with the soil, there is present in the subsoil a considerable amount of ferruginous gravel, although the proportion is not usually as great. In some small areas the surface is covered with various-sized bowlders of a ferruginous nature. Such areas, though of small extent, are too stony for cultivation and occupy only the highest elevations and steep slopes.

This soil is confined to the southeastern part of the parish, where it occurs as isolated areas usually small in extent. The most extensive areas are located south of Dolette, southwest of Naborton, and west of Pelican. These areas are under cultivation, while the majority of the smaller spots, consisting of irregular knobs and ridges, and on account of their topography seldom under cultivation, are still largely in forest. On the more level areas, however, excellent crops are grown.

This soil is thoroughly drained, as its surface configuration permits the water to run off freely, while the presence of the concretions in the subsoil allows the free movement of the soil water. No areas of this soil require artificial drainage.

The Orangeburg fine sandy loam is locally known as "gravelly land," owing to the abundance of iron concretions. It is a strong, highly productive, and desirable soil for general farming. Cotton and corn are the principal crops and good yields are obtained. From one-half to three-fourths bale per acre is the average for cotton, while of corn from 25 to 35 bushels per acre are produced. Oats and grass do fairly well.

It is believed that this soil is capable of producing a high type of Cuban seed filler leaf tobacco. On the steep, broken areas peaches and apples would undoubtedly prove profitable.

The following table gives the mechanical analyses of the fine earth of this type:

Mechanical analyses of Orangeburg fine sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10814	3 miles E. of Benson.	Brown fine sandy loam, 0 to 18 inches.	1.6	0.8	1.2	21.3	43.0	19.5	12.3
10816	4 miles S. of Naborton.	Red fine sandy loam, 0 to 15 inches.	5.4	3.4	2.3	29.8	21.3	24.3	13.6
10818	2 miles SE. of Dolette.	Red gravelly fine sandy loam, 0 to 12 inches.	13.0	8.0	3.4	21.2	11.2	23.5	19.7
10815	Subsoil of 10814	Red stiff sandy clay, 18 to 36 inches.	.7	.7	.5	14.2	23.4	12.9	42.1
10819	Subsoil of '0818	Red sandy clay, 12 to 36 inches.	7.2	7.3	3.3	12.4	5.8	14.1	49.8
10817	Subsoil of 10816	Red sandy clay, 15 to 36 inches.	2.5	2.1	1.1	5.3	8.6	19.7	60.6

ORANGEBURG SANDY LOAM.

The soil of the Orangeburg sandy loam is a dark-red sandy loam, 10 to 18 inches in depth and composed mainly of well-rounded medium to coarse quartz sand, embodied in a matrix of fine material. The surface soil contains a large proportion of ferruginous and conglomerate sandstone fragments. The subsoil is a dark-red clay, containing from 30 to 40 per cent of medium sand, which 2 or 3 feet below the surface becomes more sandy and quite friable. Fragments of the sandstone rocks are also scattered through the subsoil.

The Orangeburg sandy loam occurs as a single high ridge in the southeastern part of the parish, and embraces an area of less than 1 square mile. It is a well-drained soil, and crops are apt to suffer in times of drought. Its physiographic position causes it to wash badly, and care must be taken to prevent damage from this source. The type is sedimentary in origin, probably being the weathered product of the Lower Claiborne of Harris and Veatch. The sandstone and conglomerate rock fragments found in the soil have doubtless been formed by the cementing together of the sand and sandy clay particles by iron salts.

Corn and cotton are the principal products on this soil, both giving fairly good yields. Fruit, especially peaches, could be profitably grown; vegetables also do well.

The following table gives the results of mechanical analyses of the fine earth of typical samples of the Orangeburg sandy loam:

Mechanical analyses of Orangeburg sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
10826	4½ miles SE. of Dolette.	Red sand, 0 to 15 inches..	2.0	10.5	45.2	16.5	12.0	8.0	5.3
10828	4½ miles SE. of Dolette.	Red sandy loam, 0 to 18 inches.	1.1	11.3	42.8	14.9	11.8	12.3	5.8
10829	Subsoil of 10828	Red sandy clay, 18 to 36 inches.	1.1	11.0	36.5	11.5	8.9	10.5	20.4
10827	Subsoil of 10826	Red sandy clay, 15 to 30 inches.	.8	6.9	33.5	11.6	7.8	6.8	32.5

MILLER CLAY.

The Miller clay consists of a brownish-red or dark chocolate-colored waxy clay, with a depth of 10 inches, underlain by a subsoil of a stiff, tenacious clay, resembling the soil both in color and texture. In some cases a yellow sandy loam is found at a depth of 3 feet, while in depressions and areas which are subject to frequent and long-continued overflows a drab or blue clay forms the deeper subsoil.

The overflow water, after depositing the heavier sandy material near the stream courses, still holds in suspension the finest sediments. These are carried back into the lower parts of the bottoms, where they are gradually deposited from still water, forming the stiff clay soil mapped as Miller clay. From well borings the deposit is found to attain in places a depth of 30 feet or more, where it usually rests on a fine, light-yellow quartz sand.

The Miller clay extends in an unbroken area from Bayou Pierre River east to the Red River, a distance of 7 to 9 miles beyond the De Soto Parish line. The area lying west of Bayou Pierre River and embraced in De Soto Parish has been formed by deposition of materials from this stream and Red Bayou. The latter stream is a cut-off leaving the main river channel about 3 miles north of Evelyn, and after a circuitous route entering Dolet Bayou about 2 miles south of the same town. Dolet Bayou in turn finds its way to the main channel of Bayou Pierre River and unites with it to form the James River. The alluvial area thus inclosed embraces over 15 square miles of the most valuable and productive farming land of De Soto Parish.

While much of this type is still subject to annual overflow, the situation was greatly relieved when, a number of years ago, the opening where Red Bayou started was closed and the bulk of the water was confined to Bayou Pierre River. In this manner the flood waters are confined principally to the lower areas in the vicinity of the larger stream.

Numerous abandoned channels and old lake beds act as catchment basins for both rain and flood water, and hold it for long periods. Open ditches leading to bayous drain the farm portions, and little difficulty is experienced from excessive moisture during cropping seasons.

The Miller clay is covered with a heavy timber growth of oak, gum, whitewood, and cypress, with a dense undergrowth of shrubs, vines, and briars. But a small proportion, usually the naturally better-drained areas of this soil, is cultivated, and while the areas could be greatly extended by drainage, little effort is being made in this direction.

The Miller clay is a strong soil for corn, cotton, and sugar cane. Corn yields on an average from 40 to 50 bushels per acre, while as much as 70 bushels per acre is not an uncommon yield. Cotton produces from 1 to 1½ bales per acre in favorable seasons. Sugar cane also produces very satisfactory yields, but is not extensively grown. On the well-drained portions alfalfa has been successfully grown, as many as five cuttings being made annually. The yield varies from 5 to 12 tons per acre for the year.

Although at first this clay is very difficult to plow, after a few years of cultivation it becomes quite mellow and loamy. Deeper cultivation and the plowing under of leguminous plants are recommended as valuable aids in the improvement of the tilth. Puddling and cracking, which follow shallow cultivation, would be greatly reduced by the first expedient and rapid evaporation by capillarity materially checked, both by deepening the soil and by mixing organic matter with it.

The Miller clay sells for from $15 to $25 an acre.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Miller clay.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10820	1 mile SE. of Evelyn.	Stiff clay, 0 to 10 inches..	0.1	0.4	0.4	1.5	2.4	32.0	63.0
11919	3¼ miles E. of Frierson.	Brownish red clay, 0 to 12 inches.	.0	.1	.2	1.4	1.4	30.7	66.1
10821	Subsoil of 10820......	Brownish red stiff clay, 10 to 36 inches.	.1	.4	.3	.9	1.3	38.1	58.8
11920	Subsoil of 11919......	Brownish red stiff clay, 12 to 28 inches.	.0	.1	.2	.9	1.0	12.8	85.0

MILLER SILT LOAM.

The Miller silt loam is the second of the two alluvial soils of the area, and occupies nearly the same physiographic position as the Miller clay. The soil consists of a brown or light chocolate colored silty loam, varying in depth from 8 to 18 inches. The subsoil is composed of a heavy red silt loam, often grading into a coarser and much lighter colored fine sandy loam at about 2 feet. The Miller silt loam occupies the highest portions of the bottoms along the immediate banks of Red Bayou, and in some few places along Bayou Pierre River.

In times of high water the velocity of the current is greatly checked when the water flows over the banks, and the heavier material is deposited on the immediate banks of the stream. In this manner the " front land " is formed, while the finer material is held in suspension to be later deposited on the more remote parts of the bottoms. As the distance from the streams increases, the amount of very fine sand in the soil decreases, and at a short distance from the channel the silty soil has given place to a much heavier type, the Miller clay.

Upon the immediate bank of the stream the Miller silt loam is extremely loesslike in texture and appearance, and may attain a depth of 24 to 36 inches. Back a few yards from the channel the soil becomes more loamy, thinning out to a feather edge where it joins the Miller clay. There are therefore no extensive areas of this soil type, and no sharp line of demarcation exists between it and the Miller clay.

The Miller silt loam is a friable, easily cultivated soil. It is naturally well drained, and is one of the most productive and desirable soils in the area. It can be cultivated immediately after a rain or the subsidence of the overflow water.

All of the Miller silt loam mapped was found to be under cultivation, and the greater part has been farmed for a number of years. It was the first of the bottom lands to be cleared. Chiefly cotton and corn are grown and splendid yields are secured. When first cleared the average yield of corn ranges from 50 to 75 bushels per acre, and of cotton about 1 bale per acre. Successive cropping without rotation has lowered these yields somewhat.

Alfalfa and sugar cane do well. Vegetables of splendid quality are produced, and the loose, loamy texture, thorough drainage, and close proximity to water make this an admirable type of soil for trucking. Its present remoteness from markets and railroad facilities is the only disadvantage to its use for this purpose.

Cottonwood predominates in the timber growth, but ash, hickory, red oak, and sweet gum occur.

The following table gives the results of mechanical analyses of the soil and subsoil of the Miller silt loam:

Mechanical analyses of Miller silt loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11917	10½ miles E. of Kingston.	Dark-brown loam, 0 to 15 inches.	0.1	0.2	0.3	1.2	12.7	74.8	10.6
10624	¼ mile NW. of Evelyn.	Brown loam, 0 to 10 inches	.0	.1	.1	.3	9.4	77.8	12.2
10622	2 miles SE. of Evelyn.	Brown loam, 0 to 8 inches.	.1	.3	.2	.8	2.6	73.8	21.9
11918	Subsoil of 11917	Red sandy loam, 15 to 36 inches.	.0	.4	.2	.4	18.5	70.2	9.8
10625	Subsoil of 10624	Red heavy loam, 10 to 36 inches.	.0	.2	.1	.2	8.6	71.5	19.1
10623	Subsoil of 10622	Loam to sandy loam, 8 to 36 inches.	.0	.1	.1	.3	5.8	71.0	22.6

MEADOW.

Along all the smaller and some of the larger streams of De Soto Parish occur relatively narrow areas of light-brown or gray sandy or silty loam soils, the texture depending upon the character of the eroded areas and the sorting power of the water. These variable soils, usually underlain by mottled sandy or silty clays, have been classified as Meadow. The areas first form but a narrow strip along the streams where they originate, but gradually broaden until they may become nearly a mile in width.

In the wetter areas a phase consisting of a gray clayey silt or fine sand, streaked with iron stains, with a subsoil usually of mottled silty clay to a depth of 3 feet or more is found. This phase is usually too wet for cultivation.

As may be inferred, the Meadow is alluvial in origin and generally occupies low, flat, level flood plains, although the topography in some instances is hummocky and in some areas are high lying. On account of its position much of it is poorly drained and subject to overflow several times each year.

The more sandy and better drained Meadow soil occurs along the upper parts of many of the branches of the larger bayous and along the smaller streams of the area; it is found also between the flood plain proper and the upland escarpments. It forms an important agricultural soil, and is used for the production of cotton, corn, and sugar cane, all of which give very satisfactory yields. A bale of cotton per acre and 40 to 50 bushels of corn per acre are not uncommon yields. Sugar cane is grown only for home consumption.

These narrow strips of Meadow land are nearly always under cultivation, and are considered the best of the sandy soils. Especially during a dry season is a farmer fortunate who has a few acres of Meadow land under cultivation.

The timber growth consists of several varieties of oak, sweet gum, ash, hickory, and a few magnolias, while on the wet areas the cypress and other water-loving trees are found. These latter areas, too, afford excellent pasture, and during the winter months support a luxuriant growth of cane, upon which stock thrives.

SWAMP.

Along Wallace and Dolet bayous and their tributaries are swampy areas that are but slightly elevated above the stream level, and upon which water stands during the greater part of the year.

The soil is composed of silts, sands, and clays, and is covered with a dense growth of cypress, gum, and other water-loving vegetation. Besides the areas along the streams in the southeastern corner of the parish there are bodies of varying size in the Miller clay in the form of small lake beds and abandoned channels.

These areas could be drained, and if properly cultivated would doubtless prove very productive.

AGRICULTURAL CONDITIONS.

There is not much diversity in the agricultural products of De Soto Parish. Cotton is the one important staple—the money crop—and it is grown almost to the exclusion of the subsistence crops. Corn, oats, and hay in large quantities are annually shipped into the parish, while these products could and should be produced at home.

It can be said, however, that the one-crop idea is gradually losing favor, and farmers are beginning to realize that crops other than cotton can be profitably grown. This change has been brought about chiefly by the advent of the boll weevil, but partly through the example of a few progressive farmers who have attempted and made a success of a more diversified and of specialized systems of farming. For example, the fruit industry is being developed quite extensively in some sections of the parish. Peaches are preferred, but apples do well, and some handsome profits have been realized already from the young orchards. A great deal of attention is being paid at present to this comparatively new industry, and the outlook is quite promising. Figs also produce abundantly and could be profitably grown. Both the Susquehanna fine sandy loam and the Orangeburg fine sandy loam are recommended particularly for this purpose.

The light sandy soils of the area are admirably adapted to trucking and market gardening. Little attention, however, has been paid to the trucking industry, owing principally to the fact that there is no home market and that freight rates to more distant markets are high. If enough persons were to embark in this business to enable shipments in carload lots, trucking would be found a very profitable industry.

Melons, Irish and sweet potatoes, peanuts, and vegetables do very well upon these sandy soils. In fact, any crop adapted to a light sandy soil will produce abundantly upon these sandy hill types and yield much larger profits than are obtained from the crops now grown, provided only a market can be found for the products.

In general, these light sandy soils are deficient in organic matter, and do not retain sufficient moisture in the drier seasons fully to mature the general farm crops. This condition, however, can be greatly alleviated by the liberal use of barnyard manure, cowpea vines, or other green manuring crops. At present very little barnyard manure is used in the area, as few cattle are kept.

The use of commercial fertilizers is not general, and it is only within the last few years that the average farmer of De Soto Parish has practiced this method of enriching the soil. The profitable results are beginning to be appreciated, and the opportunity for permanent improvement of the land is also recognized. However, while the soils respond quite readily to the application of fertilizers, they are of such a nature that barnyard manure and green manuring will be found even more beneficial in increasing and maintaining their productivity. In view of the present scarcity of barnyard manure, cowpeas, which form an excellent substitute, should be more extensively used, and they can not be too strongly recommended to the progressive farmer as a means of building up his farm.

The rotation of crops is not generally practiced, but year after year the same fields are planted to the same crop, thus exhausting the soils. The land should be planted in cotton for one or two years and then sown to corn and cowpeas. The latter may be planted in the rows at the time of the last cultivation and the vines cut and dried for hay after the corn is harvested. The " Ironclad " is said to be one of the best varieties of cowpea for this region.

After reaping oats, which are sown in the fall and harvested in June, the ground can be sown to June corn and cowpeas. Crimson clover sown in October and harvested in April has produced excellent returns, while upon ground prepared in May the first cutting of a self-seeded stand of crab grass can be made in August. Another cutting can be made in October. This grass produces from 1 to 1½ tons per acre, and cures quickly and easily.

Within the last few years a few fields of alfalfa have been successfully started on the alluvial soils, and remarkably good yields have been obtained. In order to secure the best results alfalfa should be planted on a rich, well-drained soil, with the ground water at least 4 feet below the surface. These alluvial soils need no fertilizer, and at present good stands of the seedlings are obtained without artificial soil inoculation. The preparation of the soil should be deep and thorough, in order to secure a pulverulent seed bed. This can best be accomplished by disking the land both ways, which should give good tilth to a depth of 3 inches. From 15 to 20 pounds of alfalfa seed to the acre should be sown broadcast, after which the ground should be rolled and the smooth surface broken with a smoothing harrow. If the plants are thriving they should appear green, while the roots should show the presence of bacteria by the little nodules on them.

No attempts to grow alfalfa on the uplands on a commercial scale have been successful, but it is believed that this crop can be grown on some of the better-drained Meadow land and the deeper phases of both the Norfolk fine sandy loam and the Susquehanna fine sandy loam. The upland soils would require the same thorough preparation as the bottom lands, and in addition liberal applications of barnyard manure would be necessary. Artificial inoculation would doubtless be required for the upland soils. This may be done either with soil from some field that has successfully grown alfalfa, and which is known to be free from weeds and diseases, or with artificial culture, which may be secured from different seedsmen or from the Department of Agriculture.

Alfalfa yields from 6 to 10 tons per acre annually, and may be cut from five to eight times. Each cutting yields from 1½ to 2 tons per acre, and the hay is worth locally from $15 to $20 a ton. The growing of alfalfa is earnestly recommended, so that a valuable product which is at present being shipped into the parish may be produced within its boundaries.

Generally speaking, the farming class of De Soto Parish is not at present in a particularly prosperous condition. The improvements on the majority of the farms are inexpensive, consisting of small frame and log houses and a few outbuildings. There are, however, some exceptions to this rule, and well-kept and highly improved farms are seen here and there. The fences are for the most part rail, though barbed wire usually incloses the larger areas.

Of the 3,865 farms in the parish the owners operate but 32.5 per cent. The farms vary in size from 40 to several hundred acres, the average farm containing about 90 acres. About one-third of the land of the parish is under cultivation. On the larger farms negro labor is universally employed, but in recent years has been rather difficult to secure.

By planting crops at intervals a great deal of expense for labor can be saved. One farmer with three negro plow hands raised 66 bales of cotton and 1,500 bushels of corn during one season. Improved farming implements are being more and more extensively used, and to great advantage.

A few farmers have found it profitable to feed their stock, rather than let it depend exclusively upon the range for subsistence, and it is only a question of time until stock raising and dairying will develop into important industries. The bottom lands are especially adapted to this purpose, the thick underbrush and luxuriant growth of cane affording both protection and food for stock even during the winter months. Many farmers brand their stock, which roam the woods and find their own living the year round.

At present some dairying is being done in the vicinity of Stonewall, where several herds of fine Jersey cattle were seen. There are no creameries in the area, and the butter is made at home and shipped to the larger markets, where it is always in demand.

De Soto Parish contains little or no longleaf pine, but has an abundance of valuable shortleaf pine and deciduous forests. The oaks, consisting of several varieties, are most numerous. Hickory, sweet gum, ash, beech, cottonwood, cypress, and walnut occur in varying quantities. There are a few well-equipped sawmills and a number of smaller ones scattered throughout the area. Large tracts of timbered land are being held for speculative purposes, and it is impossible in some localities to purchase a small farm. The average price for unimproved upland at present is about $8 an acre. The alluvial land ranges in price from $15 to $25 an acre.

Three lines of railroad cross De Soto Parish, thus affording ample transportation facilities to the greater part of the area. The Houston, East and West Texas Railroad crosses the western part, while both the Texas and Pacific and the Kansas City Southern railroads pass through the central portion. A small line, owned and operated by a local company, connects Mansfield with the Texas and Pacific Railroad, 1¾ miles to the south. The Kansas City Southern runs half a mile east of the town.

Both the Sabine and Bayou Pierre rivers are navigable at times of high water, but are very little used for freighting purposes. Several years ago, however, boats came up the Sabine River as far as Logansport.

The wagon roads are of dirt and are generally poor. Very little work is done upon the main highways which traverse the area. These roads were extensively used for freighting purposes before the construction of the railroads. There is no good road-making material in the parish. The sandy roads are often steep, and in dry weather deep, making hauling difficult, while roads crossing the alluvial soils become almost impassable during wet weather.

SOIL SURVEY OF ANDERSON COUNTY, TEXAS.

By WILLIAM T. CARTER, Jr., and A. E. KOCHER.

LOCATION AND BOUNDARIES OF THE AREA.

Anderson County is situated in the central eastern part of Texas, and comprises a land area of 683,904 acres, or approximately 1,069 square miles. The county is of irregular outline, and is bounded on the north by Henderson County, on the east by Cherokee County, on the south by Houston County, and on the west by Leon and Freestone

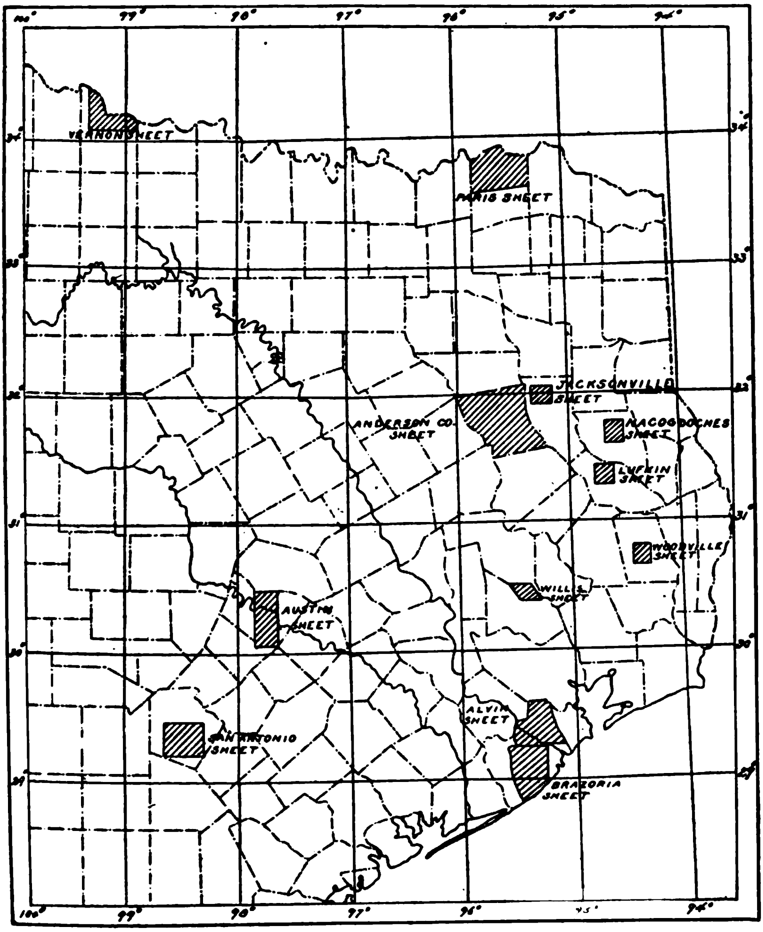

FIG. 16.—Sketch map showing location of the Anderson County area, Texas.

counties. The Neches River forms the eastern, while the Trinity River marks the western boundary of the county.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Anderson County was organized in 1846 from a part of Houston County, the latter having been formed in 1839 from a part of Nacogdoches County.

In 1837 a few immigrants from Georgia and other Southern and Eastern States made a settlement 2 miles southwest of where the town of Palestine now stands. This was the first white settlement in what is now Anderson County. At that time Indians were numerous and hostile, and the settlers had to build a fort and stockade as a protection against their attacks. This fort was called Fort Houston, a name closely associated with the early history of the State. During the first few years only a small area of land near the fort was cultivated, the products being corn and vegetables.

About 1840 the settlers commenced clearing land and building homes throughout the county. The Republic of Texas in 1836 had passed a law granting a married man a league and a labore,[a] and an unmarried man one-third of a league of land. A few years later this law was changed so that a married man received 320 acres, and an unmarried man 160 acres. No charge was made for this land, except that each man was required to pay the cost of the survey and certain small fees for certification, title, etc. Prompted by these generous concessions, immigrants from the older States—chiefly those of the South—gradually came in and settled the country, Anderson County receiving a fair share of the newcomers.

The early settlers lived in a very primitive manner. Markets and large towns were far away, and transportation facilities were crude. The first crops were corn and vegetables. In a few years, however, cotton was being cultivated, as well as enough wheat to supply the wants of the settlers. Rye and oats were also grown. In later years small mills were erected for grinding the grain, and the production of cotton increased rapidly. Up to the time of the civil war the principal crops of Anderson County were corn, cotton, oats, and some wheat. No wheat has been grown since the civil war.

The first markets were Houston, Tex., and Shreveport, La. These were reached by ox teams with heavy wagons. The Gulf ports were reached by rafting down the Trinity River. These places, although at a considerable distance from Anderson County, brought the settlers into close communication with the larger markets of the country.

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[a] A league is 4,500 acres, and a labore is 177 acres.

Cotton was the only product shipped from the county prior to the civil war.

In 1872 the first railroad, known as the International, was built through Anderson County. Two years later the Great Northern was extended through the county from Houston. Later these two roads were consolidated under the name International and Great Northern. After the introduction of railway facilities had established ready communication with outside markets, the county grew rapidly in population, a new life was infused into its agricultural industries, and land increased in value, especially near the railroads.

During the last few years it has been found that the soils and climatic conditions are favorable to the production of fruit of a high quality, and good yields are being obtained. Encouraged by the success of fruit growers in near-by counties where conditions of soil and climate are much the same as in Anderson County, quite a number of farmers near the railroads have commenced to grow fruit and vegetables for the early market. This tendency toward diversification of crops will undoubtedly be of great benefit to the farmers of this section, as they should not be so largely dependent upon the cotton crop, and the introduction of fruit and truck growing would seem to open an avenue of new and profitable employment.

CLIMATE.

The climate of Anderson County gives a long growing season, which enables the cultivation of many crops during the greater part of the year. The winters are usually mild, excessive cold weather being exceptional and of short duration. A light snow sometimes falls but soon melts away. Occasionally sudden changes in temperature are brought about in the winter by the "northers," or cold winds, which suddenly sweep down from the north and last from two to five days. The summers, though long, are not excessively hot. The cool Gulf breezes temper the heat and give a pleasant temperature during the greater part of the summer.

Anderson County lies within that region of rainfall known as the Gulf type, whose rainfall is derived from the moisture-laden trade winds which sweep westerly across the Atlantic, precipitating their moisture upon the West Indies and the Gulf region of North America. In general, the rainfall of this type is sufficient for agricultural purposes in all months of the year.

The following table, showing the mean monthly and annual temperature and precipitation, is taken from the records of the Weather Bureau stations at Palestine and Corsicana, the latter town lying about 30 miles northwest of Anderson County, and climatic conditions in the northwestern part of the county are probably represented by an average between those existing at Palestine and Corsicana:

Normal monthly and annual temperature and precipitation.

Month.	Palestine.		Corsicana.		Month.	Palestine.		Corsicana.	
	Temperature.	Precipitation.	Temperature.	Precipitation.		Temperature.	Precipitation.	Temperature.	Precipitation.
	° F.	*Inches.*	*° F.*	*Inches.*		*° F.*	*Inches.*	*° F.*	*Inches.*
January	49.8	4.31	46.9	2.64	**August**	80.4	2.68	82.9	2.12
February	51.0	3.51	49.1	2.12	**September**	75.7	3.25	77.1	3.24
March	57.6	3.98	57.5	3.85	**October**	66.5	3.22	67.1	2.61
April	66.7	4.62	66.7	3.88	**November**	56.2	4.45	55.3	3.51
May	71.3	5.84	73.6	4.50	**December**	51.4	3.81	49.0	2.40
June	78.2	4.25	80.6	3.78	**Year**	65.5	46.51	65.8	36.72
July	81.5	2.59	83.7	2.57					

In Anderson County, where the soils are essentially adapted to truck farming and fruit growing, it is important that these crops should be cultivated at such periods as to escape the early and late frosts, and with a view to placing the products on the market as early as possible. The average date of the last killing frost in spring is March 13, and of the first in fall, November 13.

PHYSIOGRAPHY AND GEOLOGY.

Anderson County lies within that part of the Coastal Plain of Texas known as the "east Texas timber belt." In general, this region is a comparatively hilly to rolling belt of sandy timber land, corresponding to the outcrop of the Eocene formations.

In surface features the eastern and western parts of the county are generally rolling and gently sloping. In the central part, extending from north to south, is a broad, ridgelike elevation, forming a divide between the drainage areas of the Trinity and Neches rivers. This central elevation is considerably broken and hilly. Large and small areas of plateaulike elevations occur through this section of the county, their summits being from 500 to 700 feet above sea level, with steep, precipitous, and rugged slopes.

The drainage systems of the Neches and Trinity rivers almost meet in the central part of the county, and many small streams start from springs in this section. These stream bottoms are narrow and deep, but in the eastern and western parts of the county the small streams combine to form large creeks with broad bottoms, which are usually only a few feet below the general surface of the country.

The general drainage of the uplands is good, except in occasional spots in the western part of the county, where a few areas, varying in size from a few acres to several square miles, are low and basinlike, and during the rainy season the water stands in these for days at a time. These low spots are locally termed "swags," or "glades," and are of little agricultural value in their present condition.

The elevation of the county varies from 250 to 700 feet above sea level. It is thoroughly drained throughout by small branches and creeks, all of which are tributary to either the Trinity or the Neches River.

In the central part, where the physiography is so broken and rugged, the hills and plateau slopes are locally termed mountains. These rugged slopes are so steep and stony that only a few of them can be cultivated.

Little can be said of the geology of this county, since no detailed geological work has been done here. It would appear, by reference to geological work done in other parts of eastern Texas, that both the Tertiary and Quaternary systems are represented in Anderson County.

A common feature of the more broken parts of the county is the presence of numerous ferruginous sandstones and large iron concretions, which occur on the surface and throughout much of the red clay subsoil. These sandstones are formed by the cementing action of iron hydrate solution, which, on losing the carbon dioxide, deposits iron around and between the sand grains, giving rise to a true cementation whenever exposed to the air.

Several miles west of Palestine a considerable bed of limestone is found. Near this limestone a deposit of salt is worked with much success by a large factory, which manufactures a fine grade of table salt from the beds. Outcrops of lignite are found in the county, and salt licks are also quite numerous. A fair grade of brick is made from the yellow sandy clay, and it is used for that purpose to some extent. The yellow clay makes a splendid roadbed through the sandy areas.

The greensand marl of the Eocene represents the Tertiary, as do also certain beds of sands and clays. A conglomerate iron ore is quite often encountered, consisting of a mass of pebbles and sand cemented by a ferruginous matrix. This probably belongs to the Quaternary, which is also represented by an overlying deposit of coarse, medium, and fine sands, occurring over a considerable area of the county, and often being several feet in depth.

The soils are all derived from beds of materials which were placed here in comparatively recent times, and which have since been reworked and reassorted by local agencies, chiefly erosion. The original beds from which the soils are derived are mostly of marine origin, representing beach deposits. The soils of the bottoms bordering the rivers and other large streams are, of course, of very recent origin, being entirely alluvial, and subject to overflow and continual additions. In the Trinity River bottom are numerous lakes, varying in size from a few acres to several hundred acres. These lakes probably mark an old river bed.

SOILS.

The soils of Anderson County are of two divisions: First, the sands, sandy loams, and clays, which are sedimentary soils derived from material principally deposited during the Eocene age; and, second, the alluvial soils, which comprise the bottom lands lying along the rivers and larger streams, composed of material of more recent deposition. These alluvial soils owe their origin to the overflow waters, which have transported the mineral and organic matter from other regions and, during inundations, deposited this material from the backset and quiet water.

The alluvial soils in Anderson County are of two kinds: First, those deposited from waters which have transported the soil matter from the east Texas timber belt of the Coastal Plain, which gives rise to the sands and sandy loam soils found along the bottoms of the Neches River and all the creeks and smaller streams in the county, and, second, those soils formed from material deposited by waters having their source in the Black and Grand Prairie regions of Texas, this class consisting of a heavy clay found bordering the Trinity River.

In all, there were recognized and mapped in Anderson County ten types of soil. The names and respective areas, both actual and relative, of these types are shown in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Norfolk fine sandy loam	224,640	32.9	Orangeburg clay	35,904	5.2
Norfolk fine sand	138,880	20.3	Lufkin clay	17,216	2.5
Orangeburg fine sandy loam	102,080	14.9	Houston clay	3,264	.5
Meadow	56,640	8.3	Yazoo sandy loam	1,600	.2
Norfolk sand	55,808	8.2	Total	683,904	
Yazoo clay	47,872	7.0			

NORFOLK SAND.

The Norfolk sand, to a depth of about 10 inches, consists of a gray or white sand, loose and incoherent, and containing but a small amount of organic matter. The subsoil consists of a sand of the same texture to a depth of several feet, but is usually yellow in color.

The texture of the Norfolk sand in Anderson County varies considerably, it being composed sometimes chiefly of a coarse and medium sand, and again of a medium and fine sand, with a small amount of coarse sand. The soil grains are very irregular in shape and size, being subangular and broken, with no characteristic form. Both the soil and subsoil are free from stones or gravel. Some small areas have a yellow sandy clay subsoil at a depth of 2 or 3 feet, which is caused by erosion, but these areas were too small to be mapped as a separate type.

The Norfolk sand occurs in several large and small areas, extending throughout the central and eastern parts of the county from north to south, the largest areas lying in the vicinity of Alderbranch, Brushycreek, Frankston, and Palestine. The type usually occupies the highest areas of the county, occurring as nearly level but gently rolling, plateaulike eminences, whose slopes are usually composed of the eroded and stony phase of the Orangeburg clay.

Owing to its loose texture and rolling topography, the Norfolk sand is very well drained. With thorough cultivation it withstands drought to a considerable extent. A fine quality of water for domestic use may be reached anywhere in this sand at a depth varying from 8 to 20 feet, and on many of the slopes good springs are found. The Norfolk sand usually occupies a position on the divide between the drainage systems of the Neches and Trinity rivers. The type is sedimentary in origin, representing old beach deposits of the Tertiary or Quaternary age.

The Norfolk sand is especially adapted to melons, pease, and other vine crops. Potatoes, peaches, and small fruits, including all varieties of berries, do well. The crops usually grown are cotton and corn, with some vegetables, peaches, plums, berries, etc. When uncleared this soil supports a natural growth of "sand-jack" oak, "black-jack" oak, pine, and some hickory.

When first cultivated the yields on this type are fair, but after a few years the soil deteriorates if no fertilizer or organic matter is added, and the yields become much smaller than at first. Under ordinary conditions the crop yields are as follows: Cotton, from one-fourth to one-half bale per acre; corn, from 12 to 25 bushels; potatoes, 40 bushels; sweet potatoes, from 100 to 150 bushels; tomatoes, 100 bushels; melons, about 1 carload, and cantaloupes, about one-fourth carload, per acre. Much of the type is too far from the railroads for truck farming.

The value of this land varies from $5 to $10 an acre, depending on location and state of cultivation. The Norfolk sand would be greatly benefited by the incorporation of organic matter by means of turning under cowpeas or other leguminous crops.

The following table gives mechanical analyses of typical samples of the soil and subsoil of the Norfolk sand:

Mechanical analyses of Norfolk sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11415	5 miles SW. of Frankston.	Gray coarse sand, 0 to 10 inches.	0.7	15.1	21.2	49.8	7.1	4.0	1.6
11417	3 miles SW. of Frankston.	Gray sand, 0 to 12 inches..	.2	8.1	22.8	54.4	6.3	4.5	3.7
10774	2½ miles SE. of Brushycreek.	Gray sand, 0 to 12 inches.	.8	7.5	22.2	44.0	11.5	9.9	4.6
11416	Subsoil of 11415	Yellow coarse sand, 10 to 36 inches.	.6	14.3	20.0	52.7	7.1	2.9	2.2
11418	Subsoil of 11417	Yellow sand, 12 to 36 inches.	.0	5.5	17.9	62.6	6.7	3.7	3.4
10775	Subsoil of 10774	Yellow sand, 12 to 36 inches.	.1	7.8	23.9	40.6	10.0	13.8	4.7

NORFOLK FINE SAND.

The Norfolk fine sand, to a depth of 12 inches, consists of a light-brown or gray fine sand, underlain by a yellow fine sand to a depth of 3 feet or more. Often both the soil and subsoil have a considerable silt content, which gives a rather loamy texture to the fine sand.

The greater part of the Norfolk fine sand has a natural growth of oak and hickory. There is one phase of the type which supports a growth of pine, and in this phase the soil is lighter in color, having a much finer sand and higher silt content than the bordering type. The texture of the subsoil is nearly the same as that of the soil.

The Norfolk fine sand is well distributed throughout the county. The largest areas are located in the southern part, in the vicinity of Salmon and Denson Spring; in the northwestern part, in the vicinity of Bradford, and in the western part, in the vicinity of Tennessee Colony. The so-called "pine woods" phase occurs in the eastern part of the county, near Neches and the Neches River. Numerous small areas are found all over the county, and along the slopes of streams there are small areas not over 100 to 300 feet in width.

In topographic features the Norfolk fine sand is gently rolling, embracing some nearly level upland, with occasional moundlike eminences of small extent. The slopes are always gentle, while the altitude varies from 300 to 500 feet above sea level. This type of soil is well drained throughout, the top soil admitting of a rapid removal of surface water by gravitation, while the loose-textured subsoil permits rapid percolation of soil water downward. This type admits of ready cultivation under almost any condition of moisture content.

The Norfolk fine sand represents one of the latest geological formations in the county. It is sedimentary in origin, being derived from beach deposits probably of Tertiary age. Erosion and other local agencies have probably exerted some influence in its formation.

The type is adapted to all crops suited to the Norfolk sand, but is a much more productive soil. All kinds of truck crops, small fruits, and peaches do well. The crops usually grown are cotton, corn, potatoes, melons, vegetables, peaches, small fruits, berries, etc. Although more productive than the Norfolk sand, this type is like it in that cultivation causes it to deteriorate in productivity unless organic matter or fertilizer is added. The growing of leguminous crops and turning them under is of great advantage. In ordinary seasons the average yields per acre are as follows: Cotton, from one-third to one-half bale; corn, from 20 to 30 bushels; Irish potatoes, 50 bushels; sweet potatoes, from 150 to 200 bushels; tomatoes, 100 bushels, and melons and cantaloupes about the same as on the Norfolk sand.

This type of soil may be purchased for from $5 to $12 an acre, according to location and condition. The soil is warm, easily handled, and responds readily to cultivation and fertilization. It is generally conceded to be more productive where the natural timber growth is hardwood than where it is pine.

The following table gives mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Norfolk fine sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10780	2 miles W. of Palestine.	Gray fine sand, 0 to 12 inches.	0.0	0.3	1.7	73.8	17.6	4.6	2.6
11419	5¼ miles SW. of Palestine.	Gray fine sand, 0 to 12 inches.	.0	.1	.6	68.0	18.7	10.0	2.6
10776	2¼ miles SW. of Neches.	White fine sand, 0 to 12 inches.	.0	.2	.2	52.2	29.8	14.5	3.2
10781	Subsoil of 10780	Yellow fine sand, 12 to 36 inches.	.2	.8	1.7	73.1	15.6	6.0	2.8
10777	Subsoil of 10776	Gray fine sand, 12 to 36 inches.	.1	.4	.2	51.5	30.4	14.4	2.8
11420	Subsoil of 11419	Light-yellow fine sand, 12 to 36 inches.	.0	.0	.9	68.6	14.4	12.7	2.9

NORFOLK FINE SANDY LOAM.

The soil of the Norfolk fine sandy loam, to a depth of from 15 to 24 inches, is a gray or light-brown fine loamy sand or light fine sandy loam. The subsoil is a yellow sandy clay, which sometimes has a mottling of gray. The depth of this soil varies greatly, but the average is probably about 20 inches. Both soil and subsoil often contain from 1 to 5 per cent of small sandstone gravel.

The greater part of this type supports a growth of hardwood, consisting of different varieties of oak, hickory, dogwood, etc., but in the eastern part of the county a phase exists which supports a natural growth of pine with a little oak and hickory. The soil of the "pine woods" phase, so-called, is somewhat finer in texture and probably has a larger silt content than that of the ordinary type, but the subsoil is the same.

The Norfolk fine sandy loam occurs in very large areas throughout the western part of the county, occupying the greater part of the Trinity River drainage area. The "pine woods" phase occurs in considerable areas in the eastern part of the county, occupying a considerable portion of the Neches River drainage area.

In physiographic features most of the type appears as a rolling upland, and has a surface drainage generally adequate for all agricultural purposes. The sandy clay subsoil is quite retentive of moisture, and when the type is cultivated sufficiently it withstands drought for a considerable period of time. In the western part of the county, however, some small areas which adjoin the Lufkin clay are so level as to be poorly drained.

The Norfolk fine sandy loam is derived from the weathering of beach deposits probably of Eocene age, the loamy appearance being due to its silt and some organic matter.

This soil type is suited to a wide range of crops. It is, however, probably best adapted to truck farming and fruit growing. It is one of the best soils, as well as the most extensive, in Anderson County, and is locally termed "gray land." Forage crops could be successfully grown, especially on the more level areas of the type. The principal crops are cotton, corn, and oats, while near the railroads some vegetables and fruit are grown for market. With good seasons the principal crop yields per acre are about as follows: Corn, from 20 to 40 bushels; cotton, from one-third to two-thirds bale; and oats, 30 or 40 bushels. Irish potatoes are produced at the rate of from 60 to 80 bushels per acre; while tomatoes yield from 100 to 150 bushels per acre. Melons and all vegetables, small fruits, peaches, plums, and pears do well. Sweet potatoes on this soil yield from 200 to 300 bushels per acre.

This is a comparatively early soil, responding readily to cultivation, and retaining fertilizers well. It is greatly improved by applications of barnyard manure, or by plowing under cowpeas or other leguminous crops, as it lacks organic matter. In the vicinity of the railroads it is valued at from $10 to $30 an acre, but farther away it may be bought unimproved for as little as $5 an acre.

The following table gives mechanical analyses of the fine earth of soil and subsoil of this type:

Mechanical analyses of Norfolk fine sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10778	4 miles W. of Palestine.	Light-brown loamy fine sand, 0 to 18 inches	0.4	0.9	1.2	38.1	35.6	21.1	2.7
10506	4 miles W. of Palestine.	Gray fine sand, 0 to 18 inches.	.9	1.1	1.6	41.6	33.4	17.2	3.8
10770	2 miles W. of Neches.	Gray fine sandy loam, 0 to 18 inches.	.1	.5	.3	42.1	32.8	19.0	5.8
11421	1 mile S. of Frankston.	Gray fine sandy loam, 0 to 20 inches.	.8	1.4	3.3	35.8	32.8	18.7	7.0
10507	Subsoil of 10506	Yellow sandy clay, 18 to 36 inches.	.8	1.3	1.1	25.6	25.9	19.5	25.6
10779	Subsoil of 10778	Yellow sandy clay, 18 to 36 inches.	.6	.6	.9	22.2	24.0	20.1	31.6
10771	Subsoil of 10770	Yellow sandy loam, 18 to 36 inches.	.1	.2	.2	26.9	23.4	16.4	32.8
11422	Subsoil of 11421	Yellow sandy clay, 20 to 36 inches.	.4	.5	1.7	23.7	19.3	20.5	33.8

ORANGEBURG CLAY.

The soil of the Orangeburg clay consists of about 4 inches of a compact red or brown sandy loam of fine texture. The subsoil is a heavy red clay, usually containing a small amount of sand. In some places, however, the sand content is large enough to give it the properties of a heavy fine sandy loam.

In Anderson County a great deal of the surface soil of this type has been removed by erosion, and the red clay is exposed on the surface. The soil usually contains from 15 to 70 per cent of small iron concretions and fragments of ferruginous sandstone, which are also found to a considerable extent in the subsoil, the sandstone often forming a layer several inches in thickness. Where the clay is exposed, the ferruginous sandstone is so abundant in the soil as to make cultivation an impossibility.

The largest area of the Orangeburg clay occurs in the central part of the county, in the immediate vicinity of Palestine. Numerous small areas of peculiar shape and irregular outline occur throughout the central and eastern parts of the county. The type often occupies narrow strips, forming a boundary between two other soil types. It occupies some well-rounded ridges and knolls, but more frequently occurs in steep and rugged slopes adjacent to streams, occupying an intermediate position between the Norfolk sand, or Norfolk fine sand, and the Orangeburg fine sandy loam. Where the topographic features are not so abrupt, as is the case with the large area near Palestine, the soil is more typical of the soil as found in other parts of the Coastal Plain.

Owing to its rolling and sloping topography, the Orangeburg clay has fine surface drainage. In fact, the drainage is often too thorough and rapid, as is evidenced by the eroded condition on the steeper slopes. The close texture and heavy nature of the subsoil would necessitate artificial drainage if the surface was level or low lying. Although the clay retains considerable moisture, the surface of the soil bakes and becomes hard during dry weather, making cultivation very difficult; thus a loss of soil water through evaporation is not readily prevented, and drought affects the crops much more quickly than on the sandy soils of the area.

The Orangeburg clay is a residual soil, derived from the weathering of greensand marl, very probably of Eocene age. The material has weathered to a considerable depth. Much of the soil in the rugged and hilly sections contains sandstone and concretions, all of which seem to possess a considerable quantity of iron.

The typical Orangeburg clay is one of the strongest of the upland soils, but in Anderson County the greater part of it occupies steep, precipitous slopes of stony clay, from which the surface soil has been removed by erosion.

Probably not more than 5 per cent of the type in the county is cultivated, the greater part being covered by forest growth. The typical soil is well adapted to cotton, corn, and oats, and fair yields of wheat can be produced. The natural timber growth is post oak, red oak, and hickory. The average yields per acre of the crops grown are as follows: Cotton, from one-half to three-fourths bale; corn, from 25 to 40 bushels; oats, 50 bushels. Wheat has not been grown for some years. It would seem that hay should do well on this type of soil. Vegetables and fruit can be grown, but the soil is not so well adapted to these crops as are the sandy soils of the county.

The value of the Orangeburg clay varies according to its location, topography, and distance from railroads. The poorer phase can be bought for $3 an acre, while some of the better areas are, when near railroads, valued as high as $10 or more an acre.

The table on the following page gives mechanical analyses of the fine earth of typical samples of the soil and subsoil of the Orangeburg clay.

Mechanical analyses of Orangeburg clay.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11427	1 mile SW. of Palestine.	Brown fine sandy loam, 0 to 4 inches.	4.7	2.8	1.2	18.4	42.0	24.3	6.3
11429	3 miles S. of Frankston.	Brown fine sandy loam, 0 to 3 inches.	.9	1.9	1.5	32.5	34.0	21.8	7.4
11430	Subsoil of 11429	Red sandy loam, 3 to 36 inches.	.7	1.2	1.2	29.2	26.8	25.9	15.0
11428	Subsoil of 11427	Red silty clay, 4 to 36 inches.	1.0	1.2	.6	10.9	24.6	40.7	21.0

ORANGEBURG FINE SANDY LOAM.

The soil of the Orangeburg fine sandy loam consists of a red, brown, or gray fine sandy loam or loamy fine sand, whose depth varies from 6 to 18 inches. The subsoil is a red sandy clay. The soil is friable and light, but the subsoil is usually quite heavy.

The soil usually contains from 5 to 30 per cent of small ferruginous sandstone gravel, which occurs mostly in the darker-colored soil and is not abundant in the gray soil. Sometimes the gravel occupies as much as 60 per cent of the soil, and here the land is locally called "red gravelly land," but the usual local name for the Orangeburg fine sandy loam is "chocolate" or "mulatto" land. This type, when newly cleared, contains considerable organic matter, which is soon removed by exhaustive cultivation.

The Orangeburg fine sandy loam is found throughout the county in both large and small areas. Much of the type occurs near Palestine, Elmtown, Brushycreek, Frankston, and Elkhart. In surface features it is gently rolling and sloping. It has excellent surface drainage. The clay subsoil is very retentive of water, which enables the type to withstand drought quite readily. Some areas occupy slopes adjacent to streams, but these are never so steep as to prevent cultivation. In areas devoted to peach culture, where the topography is very gently rolling, tile drainage would probably prove advantageous.

This soil is derived chiefly through the weathering of beach deposits of Eocene or later age.

The Orangeburg fine sandy loam is suited to a great variety of crops. It seems to be the best peach soil of the area. It is also well adapted to the production of corn, cotton, vegetables, and the small fruits, being probably the most productive upland soil in Anderson County. It is easily cultivated and its productivity is readily maintained. Near the railroads truck farming is carried on to a considerable extent on this type. Many fruit trees are being planted, although as yet only a few of them are old enough to bear. Farther from the railroads cotton, corn, oats, sorghum, and cowpeas are grown; also vegetables and fruit on a small scale. The crop yields per acre in good seasons are about as follows: Cotton, from one-half to three-fourths bale, or more under especially good conditions; corn, from 30 to 40 bushels, and sorghum, 100 gallons of sirup. The type is a splendid fruit and truck soil. Tomatoes of good shipping quality are produced at the rate of from 100 to 150 bushels, and Irish potatoes, from 60 to 100 bushels per acre. Melons and cantaloupes grow well and make large yields, as do also cabbage, onions, sweet potatoes, and other vegetables and small fruits.

The soil requires additions of organic matter to prevent its becoming impoverished, and this may best be added by applying barnyard manure or turning under leguminous crops. Alfalfa, if cultivated with care, may be grown successfully. Several cuttings a year could be obtained, which would probably aggregate not less than 3 tons of hay per acre when the rainfall is sufficient. It is probable also that a good grade of cigar tobacco could be grown, judging from experiments made on this type of soil in other counties. Nearly all of the Orangeburg fine sandy loam is under cultivation. Where uncultivated, it supports a natural growth of red oak, blackjack oak, hickory, and some walnut.

Good land of this type from 6 to 10 miles from a railroad may be purchased for $8 or $10 an acre. Near the railroads and in the vicinity of Palestine it is considerably higher.

The following table gives mechanical analyses of the fine earth of typical samples of this soil:

Mechanical anaylses of Orangeburg fine sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11423	2 miles W. of Palestine.	Brown fine sand, 0 to 12 inches.	0.6	0.9	1.0	30.1	46.6	14.7	6.0
10772	2 miles SE. of Elmtown.	Brown fine sandy loam, 0 to 18 inches.	.3	2.8	5.6	30.1	31.0	22.9	7.0
11425	2 miles S. of Frankston.	Brown fine sandy loam, 0 to 18 inches.	.7	1.0	2.5	31.8	20.5	36.1	7.6
10773	Subsoil of 10772	Red sandy clay, 18 to 36 inches.	.1	1.9	4.7	23.9	24.4	17.2	27.8
11426	Subsoil of 11425	Red sandy clay, 18 to 36 inches.	1.0	1.0	1.4	20.3	14.2	29.9	32.1
11424	Subsoil of 11423	Red sandy clay, 12 to 36 inches.	.7	.8	.8	16.4	23.7	18.1	39.4

YAZOO CLAY.

The Yazoo clay, to a depth of 12 inches, consists of a dark-drab or black sticky clay, underlain by the same material to a depth of several feet. The subsoil occasionally has a slight brownish-yellow mottling. Sometimes a small quantity of sand is found in the clay in the vicinity of the Trinity River, but not sufficient to alter to any great extent the clayey texture of the soil and subsoil.

The Yazoo clay occurs along the Trinity River in the western part of the county. It forms a low, heavily timbered bottom, from half a mile to 3 or 4 miles in width, appearing as a long, continuous area, except where the river occasionally touches the upland. It comprises level or nearly level bottom land. At the banks of the river the bottom is slightly higher, with a shallow, sandy covering. The sandy areas, however, are very small in extent.

This soil type is subject to overflow from the Trinity River. These overflows occur usually in the winter and spring months, though occasionally in the summer. Owing to the level surface of the soil it requires some time for the water to drain off and the soil to become dry enough for cultivation. However, with ditching the greater part of this type can be cultivated, while some portions do not need to be drained for cultivation. During an overflow the water extends over the whole area of this clay soil to a depth varying from 4 to 8 feet, and may remain for several days. It is believed that when the Trinity River has been dredged out for navigation, a much larger amount of water can be held within its banks, and that overflows will not be so frequent nor so extensive as they have been heretofore. These overflows seldom come so late in the spring as to prevent cultivation.

The Yazoo clay is alluvial in origin, being built up by the deposition of the fine-grained soil particles from the backset waters of successive overflows of the Trinity River. These soil particles are brought from the Black and Grand Prairie regions of Texas, where the erosion caused by rainfall has denuded the productive prairie lands to a considerable extent. The fallen leaves from the trees and other organic matter have become incorporated with this soil, making it very rich and productive. Thus by successive accumulations of clay, silt, and organic matter, this remarkably productive but little utilized soil type has been formed.

The greater part of the Yazoo clay in Anderson County is uncultivated, being covered with a valuable timber growth consisting of pin oak, bur oak, pecan, ash, elm, gum, and haw. Where cultivated it is especially adapted to cotton and corn, and will produce one bale of cotton, or even more, per acre, and from 60 to 70 bushels of corn. At present the Yazoo clay is utilized principally for cattle grazing and the raising of hogs. A good growth of mesquite grass affords adequate grazing the greater part of the year. The abundant mast, consisting of acorns, pecans, and haws, makes excellent feed for hogs.

Most of this type lies at a considerable distance from the railroads. It can be bought in large tracts, varying in price from $3 to $8 an acre. A number of small lakes appear here and there throughout the Yazoo clay, and it is thought that a chain of these lakes west of Palestine marks the course where the river at one time flowed.

The following table gives mechanical analyses of the soil and subsoil of the Yazoo clay:

Mechanical analyses of Yazoo clay.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11433	3 miles NE. of Wildcat Ferry.	Dark-gray silty clay, 0 to 12 inches.	0.2	0.3	0.4	4.0	6.3	63.1	25.7
13045	12 miles SW	Dark-drab clay, 0 to 12 inches.	.0	.6	.8	8.7	4.5	27.2	57.8
11434	Subsoil of 11433	Dark-gray silty clay, 12 to 36 inches.	.5	.9	.5	3.2	6.3	64.5	24.1
13046	Subsoil of 13045	Dark-drab clay, 12 to 36 inches.	Tr.	.6	.8	10.4	5.2	32.6	50.3

LUFKIN CLAY.

The Lufkin clay is known in Anderson County as "swag land." The typical soil consists of 8 or 10 inches of a compact gray loam, or very fine sandy loam, underlain by a heavy impervious clay, whose color is a mottled gray and red or gray and yellow, containing a considerable quantity of silt. Throughout the type are scattered numerous small areas of fine sand, which are too small to map separately.

The Lufkin clay occurs in areas which vary greatly in size, some being but a few acres, while others are 2 or 3 square miles in extent. It is always surrounded by the Norfolk fine sandy loam, and is found chiefly in the western part of the county. The most typical areas are in the immediate vicinity of Tucker. The type occupies basin-like areas, lower than the surrounding country, these areas being locally termed "swags."

The low-lying position of the type prevents thorough or adequate surface drainage, while the dense clay subsoil allows only a very slow passage of soil water downward. With heavy rainfall these low-lying areas become shallow ponds, the water standing on the surface for a long time. The "swags" are easily drained by ditching, and tile drainage could be established without difficulty.

The origin of the Lufkin clay is not well understood, but it is probably sedimentary, and represents material deposited in comparatively still water. It would seem, from the appearance of the low-lying areas which form this type, that they were at one time beds of small lakes.

Where the Lufkin clay is drained it produces good grain crops, such as oats and corn, while cotton does fairly well. On account of its poorly drained condition, only a small portion of it is cultivated. It is covered for the most part with a thin growth of post oak trees of considerable size.

The Lufkin clay is considered of little value by many farmers, on account of its poor drainage, but when drained and cultivated it produces good crops, and as the sandy material of adjacent soils is gradually mixed with the heavier and poorly drained soil, in a few years the type becomes very productive and profitable for general farming purposes.

When cultivated for a period of two or three years it produces from 25 to 35 bushels of corn and from one-half to three-fourths bale of cotton per acre. It is claimed that with continued cultivation the soil increases in productiveness, which is no doubt due to thorough aeration and the removal of deleterious salts which have accumulated in the soil. It would seem that a great deal of forage, such as grasses or sorghum, could be grown with profit on this land if it were drained. The Lufkin clay is valued at from $4 to $10 an acre.

The following table gives mechanical analyses of typical samples of the Lufkin clay:

Mechanical analyses of Lufkin clay.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11413	¼ mile W. of Tucker.	Gray loam, 0 to 8 inches..	0.2	0.4	0.8	18.0	25.2	40.8	14.4
11411	¾ mile W. of Tucker.	Gray loam, 0 to 8 inches..	.0	Tr.	1.3	17.4	23.5	41.0	16.8
11414	Subsoil of 11413	Gray clay, 8 to 36 inches..	.2	.4	.8	15.2	19.7	26.5	36.6
11412	Subsoil of 11411	Gray clay, 8 to 36 inches..	Tr.	.6	.7	12.9	18.3	26.9	40.2

HOUSTON CLAY.

The Houston clay is unimportant in Anderson County on account of its very limited extent. The soil, to a depth of about 8 inches, is a brown or drab clay, while the subsoil is a yellow or yellowish-brown clay. Both soil and subsoil contain lime concretions.

Most of this type is located in the western part of the county, and occupies narrow strips or slopes where the upland joins the Trinity River bottom. One small area occurs near the salt works, several miles west of Palestine, and at this place a limestone formation is found just beneath the surface.

The Houston clay is gently rolling in topography and has excellent surface drainage. It retains considerable soil water, but this can not be readily held during droughts on account of the hard and compact nature of the soil. The type is residual in origin, being derived from the weathering of calcareous deposits.

Little of the Houston clay is cultivated, most of it being covered with a growth of mesquite grass, which affords excellent grazing for stock. In good seasons it produces from one-half to 1 bale of cotton and from 40 to 60 bushels of corn per acre, but the average is much below these figures. This land is valued at from $8 to $15 an acre.

The following table gives mechanical analyses of typical samples of the Houston clay:

Mechanical analyses of Houston clay.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11409	3¼ miles NE. of Wildcat Ferry.	Brown clay, 0 to 10 inches.	0.2	0.3	0.4	5.0	11.5	44.8	37.8
11410	Subsoil of 11409	Yellow clay, 10 to 36 inches.	.4	.9	.5	3.7	6.9	48.1	39.0

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 11409, 1.84 per cent; No. 11410, 6.52 per cent.

YAZOO SANDY LOAM.

The Yazoo sandy loam is another soil type of very limited extent in Anderson County. Both the soil and subsoil have a very variable texture. The soil has a depth of about 10 inches, consists of a brown, fine sandy loam, and is underlain by a heavy black clay. Sometimes the subsoil is a gray sandy loam to a considerable depth before reaching the black clay.

This soil type is nearly level in topography and is located along the Trinity River bottom in the western part of the county, along the line of contact between the bottom land and the upland. It forms a very narrow strip, usually too small to be indicated on the map.

The type is fairly well drained and is inundated only by unusually high overflows. A little ditching is sometimes necessary to secure the best crop results.

The Yazoo sandy loam is formed by deposits from the river and by wash from backset overflow waters, while the sandy soil is a wash from the sandy soils of the upland. The Yazoo sandy loam is simply Yazoo clay with varying amounts of sand washed on it by local agencies.

Owing to the ease of cultivation and to its productivity this is a favorite soil in the area. It will produce a bale of cotton to the acre, from 40 to 50 bushels of corn, and a fine yield of sugar cane.

The following table gives a mechanical analysis of a typical sample of this soil:

Mechanical analysis of Yazoo sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11431	2 miles SW. of Tucker.	Brown fine sandy loam, 0 to 8 inches.	0.2	0.2	0.6	29.6	35.6	29.4	3.8
11432	Subsoil of 11431	Black fine sandy loam, 8 to 36 inches.	.1	.3	.6	27.4	29.4	35.8	6.4

MEADOW.

Meadow is a very important type of soil in Anderson County. It is quite variable in texture, but in general it consists of a sandy loam or sand, usually brown in color, and extending to a depth of several feet.

This type is always found as a bottom along streams, and as Anderson County has a large number of creeks and branches few farmers are without a small area of this type of soil. The largest areas of Meadow occur along the Neches River, and Box, Town, Lake, Ioni, Mansons, Keachie, Brushy, Stills, Wells, and Catfish creeks.

The surface of the Meadow is usually level, or nearly level, the point of contact with other soils being quite sharply defined. The stream bed is usually several feet below the lowest part of the bottom, but being very narrow overflows are not infrequent. Owing to the low-lying position of the areas, the surface drainage is often very poor, but by ditching they may be easily drained, except in seasons of heavy rainfall, when the whole of the type is submerged to a depth of several feet. These overflows may occur at any time during the year, but are more frequent during the winter and spring months.

The Meadow soil is entirely alluvial in origin, being built up by successive deposits from overflow waters, these deposits being transported from all the surrounding soils through which the stream and its tributaries have passed.

As a general thing, considerable corn, cotton, and sugar cane are produced on the Meadow land, this being especially true along the smaller streams and around the headwaters of larger ones, where the overflows are much less frequent than farther down. By a little ditching the poorly drained areas of Meadow can be put in good condition for cultivation. On this type of soil corn yields from 30 to 50 bushels and cotton from one-third to 1 bale per acre. Sugar cane does especially well, usually producing from 300 to 500 gallons of good sirup per acre, for which there is a ready sale at 50 cents a gallon.

The Meadow also makes excellent pasturage, and it would seem that hay might be grown successfully. The natural timber growth is pin oak, gum, and other water-loving trees.

AGRICULTURAL METHODS.

The majority of the farmers in Anderson County are engaged in general farming, the principal money crop being cotton, while corn and oats are next in importance. Large quantities of cowpeas are also grown, both to improve the land and as feed for stock, being used largely for fattening hogs. Within the last few years considerable interest in fruit growing and truck raising has been shown, but as yet this phase of agriculture has been confined to areas near the towns and railroads, where transportation facilities are adequate.

There seems to be no systematic method of crop rotation. Cotton and corn are planted, either successively or alternately, year after year on the same land. A crop of cowpeas is occasionally grown, however, and is of great benefit to the cotton and corn land.

Owing to the sandy nature of most of the soils in the county, it is seldom that more than one horse is used in plowing or cultivating. The turning plows are of small size, varying from 6 to 10 inches. In the spring the lands which are low lying and need drainage are plowed in beds to allow surface drainage. This, however, is too often done merely to prepare the land for cultivation, the corn or cotton being planted on these beds without further preparation of the soil. The land should be broken in the winter, not later than January. This enables the soil to hold a considerable part of the winter rainfall. Then in the spring, when ready for planting, the soil should be well harrowed in order to kill the young weeds and grass, and to prepare the seed bed. After the seed comes up the soil should receive frequent but shallow cultivation. A great mistake is made by many farmers in cultivating too deeply, causing the soil to dry out to a considerable depth.

Good cotton gins are located throughout the county at convenient places, and gristmills are usually operated in connection therewith, where much corn is converted into meal.

AGRICULTURAL CONDITIONS.

The farming class of Anderson County, as a rule, are not in a highly prosperous condition, although they seem to live easily and to be supplied with all the necessaries of life. Along the railroads general farming is still practiced to a considerable extent; but it is giving way to a system of diversification and specialization, and those who are introducing fruit and truck growing into their agricultural system, instead of confining their efforts to the production of cotton and corn, are becoming more prosperous. This is evidenced by the better houses and farm buildings which are being erected throughout the county in close proximity to the railroads and by the flourishing condition of the small towns along the railroads, which are shipping points for the producers.

Lands are steadily increasing in value over the greater part of the county. The total valuation of farm lands and improvements, except buildings, in Anderson County is more than $1,500,000, while the additional value of farm buildings, implements, and machinery amounts to over $800,000. The value of live stock and domestic animals is nearly $1,000,000. The total valuation of taxable property in the county is about $7,618,000. In 1900 there were nearly 160,000 acres of improved land, and there is considerably more at the present time. In 1900 the value of orchard products was $46,000, but now it is very much greater, and many new orchards have not yet begun to bear. The annual value of forest products is about $70,000. About two-thirds of the land in the county is not improved or cultivated.

Probably 50 per cent of the farms are cultivated by tenants, who grow cotton and corn and pay as a rental a certain share of the crops. The farms are usually rented on the "third and fourth" system, or the "half" system, few tenants renting on a cash basis. Under the "third and fourth" system the tenant furnishes everything but the land and buildings and pays as a yearly rental one-third of all the corn and one-fourth of all the cotton produced. Under the "half" system the tenant is furnished land, buildings, teams, seeds, and implements and pays a yearly rental of one-half of all the cotton and corn produced. Negroes form a large proportion of the share tenants.

The farms of Anderson County are usually of small size, varying from 25 to 125 acres, and are what might be termed "one-family" farms. According to the census of 1900 the average size of farms in the county is 112 acres; but in the census classification every tenancy was tabulated as a farm, and the actual size of individual holdings must be much greater than this.

In cotton farming the work is done almost entirely by the farmer and his sons, except at particular times. Hired labor is rather cheap, but often uncertain. In the very busy seasons the labor employed is usually colored. During the spring the farmer needs extra help to "chop" or thin out his cotton, the price paid by the day being from 50 cents to $1, with partial board, while hands employed by the month are paid from $10 to $15, with board. Much extra labor is also required in the fall for cotton picking, which is paid for according to the amount picked. The price varies from 50 to 70 cents per 100 pounds, without board, depending greatly on the market price of cotton and the available supply of labor.

The principal products of Anderson County have been, for many years, cotton, corn, oats, vegetables, fruit, and live stock. Cotton was the only product exported until a few years ago, the corn, oats, vegetables, fruit, and live stock being all consumed or utilized in the county. In recent years, however, as has already been stated, with the advantages of good transportation facilities, the farmers, where favorably located, have been giving much of their attention to fruit growing and truck raising. The great cotton pest, the boll weevil, has seriously damaged the cotton industry, and this has had a tendency to increase the diversification of crops. Many peach orchards have been planted, although there are only a few as yet in full bearing. The annual value of dairy products, consisting chiefly of milk and butter consumed on the farm, is over $150,000. A more extensive system of dairying in the vicinity of the towns would likely prove profitable. Large quantities of tomatoes, Irish and sweet potatoes, watermelons, cantaloupes, onions, cabbage, peanuts, peas, beans, cucumbers, etc., are being produced. Some of these products are shipped to distant markets. During the present season (1904) about 60 carloads of garden truck and fruit were shipped from Palestine, 51 cars from Elkhart, 26 from Neches, 10 from Frankston, and about 12 from Salmon. These were largely freight shipments, but some were made by express, and consisted chiefly of tomatoes, Irish potatoes, watermelons, cantaloupes, peaches, and miscellaneous vegetables, the most profitable being tomatoes and Irish potatoes. The peaches grown are the Elberta, Mamie Ross, and a few other varieties. The fruit and trucking interests are likely to increase every year, and it is safe to say that a cannery would prove profitable in this section. The fruit and vegetables not available for shipment could thus be saved with profit. Even a small canning outfit, such as is used by the Maryland truckers, could be operated successfully by the individual farmer.

Sorghum does well on the upland soils, producing as much as 100 gallons of sirup per acre. The meadow along the creeks is especially adapted to sugar cane, producing large yields of sirup. It is a profitable crop, the sirup being manufactured by the farmer.

Hogs and cattle are allowed to run at large. The hogs fatten readily on acorns, with additional feeding of cowpeas, corn, and peanuts. The cattle do considerable grazing during the winter, but are fed to some extent. Little attention is paid to improved stock, although some farmers are introducing improved breeds of hogs and cattle. Only a small quantity of oats is raised, and the crop is not thrashed, but is fed in the bundle. No wheat is grown, and only a few small patches of tobacco are seen in the county. The farmers depend on corn fodder, sorghum, and grass for their forage, and it is not uncommon for farmers to buy hay which has been imported from the hay-producing sections of Texas. This is a mistaken policy, as a great saving could be made by growing sufficient forage in the county. Alfalfa is beginning to be grown on a small scale, while Japanese clover grows wild over a considerable portion of the county and affords fair grazing. In the Trinity River bottoms there is a fine growth of mesquite grass.

Every farmer owns a good supply of live stock, such as horses, mules, cows, and hogs, but there are only a few sheep.

Two railroads traverse Anderson County, the principal one being the International and Great Northern, which enters the eastern part, passes through Palestine, and from there through the south central part of the county. The Texas and New Orleans Railroad passes through the northeastern corner of the county. These railroads are in close communication with all the large markets of the country, St. Louis, Kansas City, New Orleans, Dallas, Galveston, and other large cities being quickly reached. The railroads are doing their part toward improving agricultural conditions in the county and are encouraging truck farming and fruit growing in every possible way.

The wagon roads in the county are yet in poor condition. In dry weather the sand becomes deep, while with heavy rains deep gullies are washed out in the roadbeds. The county roads, however, are now being improved by convict labor. The yellow sandy clay found throughout the county makes an excellent roadbed when packed properly.

The principal markets for agricultural products are Kansas City, St. Louis, Dallas, and other large western cities. Cotton is marketed in Palestine, and is usually shipped to Galveston, where it is sent to different parts of the world.

Palestine, the county seat, situated in the center of the county, is a thriving railroad town of 8,000 or 10,000 inhabitants. Elkhart, in the southern part, Neches, in the eastern part, and Frankston, in the northeastern part of the county are railroad towns and important shipping points. The general offices and machine shops of the International and Great Northern Railroad are located at Palestine, and give employment to a large number of men.

Truck growers' associations have been formed at Palestine and other towns. These associations usually consign shipments to commission men. A portion of the potato crop is sold on the track to buyers, and it is believed that an extension of this method to other vegetable products will prove profitable to the farmers, as they are often misinformed as to market conditions at distant points, and as a consequence sometimes realize only a small margin of profit, or meet with actual loss, instead of making a reasonable profit on their shipments.

SOIL SURVEY OF THE AUSTIN AREA, TEXAS.

By A. W. MANGUM and H. L. BELDEN.

LOCATION AND BOUNDARIES OF THE AREA.

The Austin area comprises a rectangular section of 705 square miles. The greater part of Travis County and parts of Williamson, Bastrop, Caldwell, and Hays counties are included in the survey. The area is located southeast of the center of the State and embraces the eastern two-thirds of the Austin sheet, United States Geological

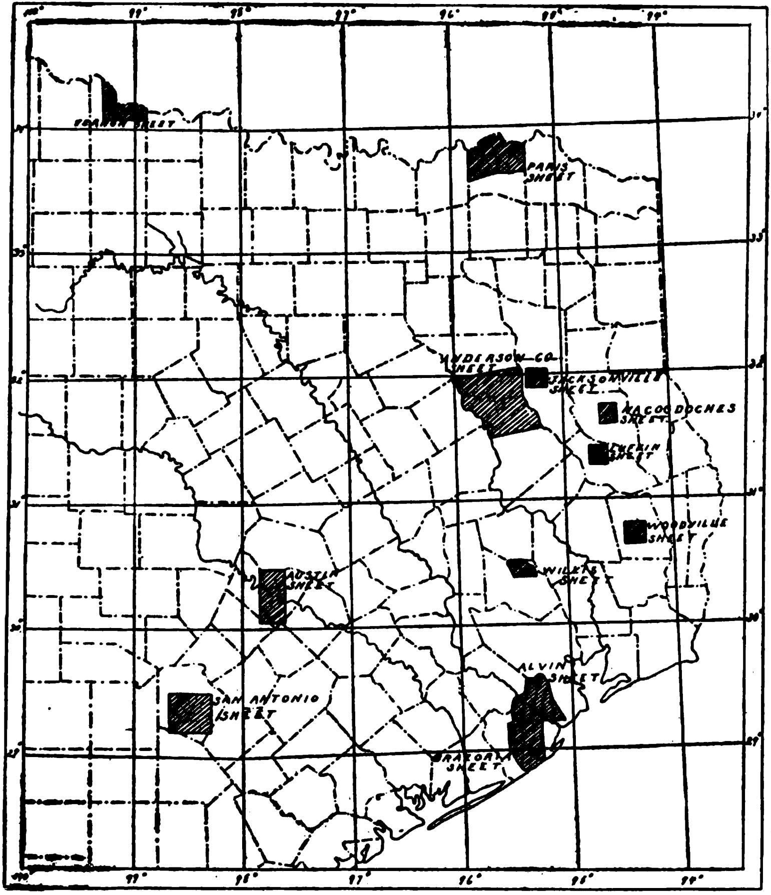

FIG. 17.—Sketch map showing location of the Austin area, Texas.

Survey. It is bounded by parallels 30° and 30° 30′ N. and meridians 97° 30′ and 97° 50′ W.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The first settlement in the area was made about 1836 and was planted by a few pioneers who had pushed forward to the extreme frontier. In 1839 the Texan congress appointed five commissioners to select a site for the capital of the Republic of Texas. They chose the location of the present city of Austin, on the Colorado River. At that time this was the northwest frontier of that part of Texas settled by the whites, the country north and west being still in the possession of the Indians. The nearest settlements of any size were Bastrop on the east and San Antonio to the southwest.

The capital was thus located with a view to drawing at once to the frontier a population large enough to serve as a protection against probable attacks by the Indians. A large settlement was soon established, and the country in the immediate vicinity of Austin was rapidly occupied, small areas of land being put under cultivation. In 1850 the population numbered 2,336, but a comparatively small amount of land was cultivated, as those who were not connected with the affairs of government or had no business interest in the town were engaged chiefly in stock raising, the broad prairies, covered with native grasses, and the mild climate being well suited to this industry.

Cotton was grown in small quantities very soon after the area was settled, but lack of transportation facilities and distance from markets prevented extensive cultivation, and only a very small acreage was devoted to its production. In 1858 the total white population was 8,386, an increase of 6,050 in eight years. Property values had also risen rapidly, improved lands being valued at from $5 to $100 and unimproved lands at from $2 to $25 an acre. Cotton and corn were the crops cultivated, with a small acreage of wheat and oats.

Although the number of cattle in the area increased in the eight years following 1850 only from 12,000 to 17,000, the rise in land values and the large increase of population indicate an increased area of cultivated land. Among the settlers were a few Swedes, who located on the black prairie lands east of Austin and are now among the most prosperous farmers in the area.

The cultivation of cotton soon began to receive more attention, and the acreage devoted to the crop gradually increased. In 1859 patent reapers were coming into general use in the harvesting of wheat and oats, and there was a demand for farm labor at good prices. As the cultivation of cotton and grain grew in importance the amount of land devoted to grazing purposes rapidly decreased, and the cattle industry began to die out, the black prairie lands being too valuable agriculturally to be used as cattle ranges. However, the rough, hilly section west of Austin was still devoted exclusively to stock raising, as it was but poorly suited to cultivated crops.

In 1871 the Houston and Texas Central Railroad reached Austin, and five years later the International and Great Northern entered the city. In 1904 the Missouri, Kansas and Texas Railroad extended a branch line to Austin. The facilities furnished by the railroads for transporting products early made Austin a center of trade for the surrounding country. As the productiveness of the soil and the mildness of the climate became more widely known, large numbers of settlers and home seekers came to the area from the more northern and eastern States.

The area is purely an agricultural section, there being no manufacturing industries of importance. A dam constructed in 1893 across the Colorado River above Austin, for the purpose of furnishing water power for manufacturing, as well as to irrigate the level bottom lands along the river, was destroyed by flood in 1900.

The agricultural interests of the area have gradually become centered in the production of cotton, almost to the exclusion of all other crops, and although small areas cultivated to corn, wheat, oats, sorghum, Johnson grass, or vegetables are often seen, the conditions seem most favorable to the successful specialization of cotton.

CLIMATE.

The climate of the Austin area is mild and healthful. Warm weather begins early in March and lasts until November. The oppressiveness of the summer heat is to some extent counteracted by the south winds which prevail during most of the year. These serve to equalize the temperature, making the winters warmer and the summers cooler.

During January and February sudden changes of temperature are frequently experienced, caused by north or northwest winds, locally known as "northers." These come down across the Great Plains and often cause the temperature to fall many degrees in a very short time. The ground very seldom freezes at all, and then only on the surface. There is no season of the year at which conditions are such as to interfere with plowing.

There is usually sufficient rainfall for the production of the crops grown, although they often suffer greatly from droughts in the summer months. The normal monthly and annual temperature and precipitation, as observed at Austin and Duval, are shown in the table on the following page, taken from records of the Weather Bureau.

Normal monthly and annual temperature and precipitation.

Month.	Austin.		Duval.		Month.	Austin.		Duval.	
	Temperature.	Precipitation.	Temperature.	Precipitation.		Temperature.	Precipitation.	Temperature.	Precipitation.
	° *F.*	*Inches.*	° *F.*	*Inches.*		° *F.*	*Inches.*	° *F.*	*Inches.*
January	48.7	2.47	50.6	2.00	August	84.1	2.48	85.2	1.88
February	52.7	1.88	53.8	1.39	September	78.6	3.72	79.7	2.88
March	60.2	2.22	61.4	1.94	October	69.3	2.77	70.6	3.01
April	69.0	4.05	69.4	4.05	November	59.0	2.26	60.0	2.82
May	76.5	4.40	76.2	3.77	December	52.2	2.70	53.3	2.28
June	82.2	2.51	83.3	2.75	Year	68.1	33.71	[illegible]9.1	30.17
July	85.1	2.30	85.9	1.90					

PHYSIOGRAPHY AND GEOLOGY.

There is a great topographic difference between the northwestern portion of the area and the eastern four-fifths. The latter section lies wholly in the black prairie belt, except for a small area in the southeastern corner which is crossed by the east Texas timber belt. A hilly region extends across the area just west of Austin, following a northeast and southwest direction. This section presents a rough and broken topography, the hills rising in a series of terraces, in places almost bare of soil or vegetation, to an elevation of 900 to 1,000 feet above sea level. Small streams which are dry part of the year have eroded deep, canyonlike erosions in the valleys between the hills. The hills are quite uniform as to height, and are flat or gently rounded on the summit of the last terrace. Cedar, with a few small areas of scrub oak, is the principal growth of this section. To the northeast and southwest of the hills are two small plateaus of a less rugged character. They have an elevation of about 800 feet above sea level, and are cut by numerous deep canyons. The hillsides are steep and rocky, but are covered with a thick growth of post oak, scrub oak, and cedar.

Beginning abruptly at the foot of the hilly region the black prairie belt stretches to the eastward. This consists of a gently rolling prairie with low, rounded hills, having the general appearance of a level plain. The valleys are wide and shallow, except along the course of the larger creeks, which in many places have cut deep gorges with perpendicular bluffs of limestone or calcareous clays that often rise to a height of 30 or 40 feet above stream level. The average elevation of the prairie is about 600 feet above sea level, a few ridges in the northeastern and southwestern portions rising to 700 feet, while the lowest point, where the Colorado River leaves the area, is 375 feet above tide level. The entire area, with the exception of small portions along the northern and southern boundaries, is drained by the Colorado River, which flows through it in a southeasterly direction. Onion Creek, its main tributary within the area, drains almost the entire southwestern portion, while Cedar, Walnut, and Gilleland creeks serve to carry the excess water of the remainder of the area to the Colorado River. These streams, unlike the river, have very small areas of bottom lands along their courses. They generally flow between steep, perpendicular limestone or marl clay bluffs, which seldom widen out sufficiently to permit alluvial deposition to any great extent. The bottom lands along the river are wide and level, extending some distance from each bank, and are among the most productive lands of the area.

The geological formations which underlie the greater proportion of the area, and which form, by their disintegration, a number of the soil types, belong to the Montana, Colorado, Fredericksburg, and Trinity divisions of the Cretaceous period. The hilly region west of Austin is composed of alternate layers of hard and soft limestone, together with layers of a shaly formation containing many fossils and alternating with a marly material. The difference in the weathering of the hard and soft material causes the terraced appearance of the hills. These belong to the Glenrose formation of the Trinity division. The topography of the area covered by this formation is so steep and rugged as to render it unfit for agricultural purposes. Only a thin layer of soil is present on the more level ridges, and this is of a very stony character.

The small plateaus northeast and southwest of the hills are underlain by the Edwards limestone of the Fredericksburg division, which consists of a series of beds of hard white limestone and flint. The surface has a large amount of flint and limestone fragments scattered over it. The latter are known as honeycombed rocks, as the limestone, originally composed of both hard and soft material, upon the dissolution of the soft spots presents a honeycombed appearance. Iron is present in small amounts, giving a reddish tinge to the soils formed by its disintegration. The limestone burned at the limekilns near McNeil is also derived from this formation.

East of the Glenrose and Edwards formations and extending both north and south of the city of Austin is a wide belt of country formed from a soft, chalky fossiliferous limestone lying in horizontal layers of varying thickness. This is known as the Austin chalk formation, and is included in the Colorado division of the Gulf series of the Upper Cretaceous. It weathers into a soft, chalky mass that lies at a slight depth below a shallow covering of soil, and is frequently exposed at the tops of the rounded hills and along their steeper slopes.

The level black prairie belt which extends across the eastern part of the area is derived from the Webberville and Taylor marl formations. They belong to the Montana division of the Upper Cretaceous, are composed of beds of calcareous clays and clay marls, and weather into a heavy black soil, very easily eroded. These formations are of great thickness, being estimated to be over 500 feet deep.

In the extreme southeastern corner of the area the sandstone, sand, and laminated red and brown clays, formed from the Lytton formation of the Eocene period, are found. The sandstone occurs in thin layers, and usually takes a reddish tinge when in a state of decomposition.

The higher ridges in the black prairie belt are often capped by a gravel deposit, which in many cases is deep enough to interfere with the agricultural value of the land. These are remnants of the Uvalde gravel deposits, which once covered a much larger territory. This formation is of the Neocene period. The gravel is rounded, and varies in size from small pebbles to cobbles several inches in diameter. Where this gravel deposit has worn down to the underlying clay formation the land is often very successfully cultivated, although the layer of gravel on the surface makes the soil very gravelly. The gravel is usually deepest on the summits of the ridges, often making them less suitable for cultivation than for pasture.

The gravelly areas on the bluffs and rounded hills in the vicinity of the river are composed of material of still more recent time, which was deposited by the river as terraces. Southeast of Austin, in the midst of the black prairie lands, are the remains of an ancient volcano It rises a hundred feet or more above the surrounding plain, and is covered with fragments of basalt of various sizes, scattered over the surface and imbedded in a stiff, reddish-brown clay soil.

Very few of the above formations have at present any economic value. Some of the harder varieties of limestone are being extensively used for building purposes, but few of them are of a durable character. The fine alluvial deposits along the Colorado River are being used in the manufacture of brick. Although a number of borings for oil and asphaltum have been made in the northern part of the area with varying results, nothing has been obtained in paying quantities up to the present time.

SOILS.

Nine types of soil were mapped in the area. Three are alluvial, the other six being formed directly from the underlying rock formations. The table following gives the extent of each type.

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Houston black clay	190,400	42.2	Lufkin fine sandy loam	24,640	5.5
Austin clay	61,440	13.6	Travis gravelly loam	13,312	3.0
Colton stony clay	56,256	12.5	Yazoo clay	11,840	2.6
Houston gravelly clay	36,672	8.1	Yakima stony clay	896	.2
Yazoo sandy loam	30,336	6.7	Total	451,200	
Rock outcrop	25,408	5.5			

HOUSTON BLACK CLAY.

The Houston black clay is the typical black prairie soil of the Austin area. Its gently rolling topography, natural productiveness, excellent drainage, and general adaptability to all crops grown make it the most important soil type recognized in the area. The soil to a depth of 12 inches is a dark-brown to black clay, containing a large amount of organic matter. When it has been continuously cultivated for some years the soil becomes loose and friable, but when wet it is very stiff and tenacious. The subsoil from 12 to 36 inches is a stiff, tenacious light-brown clay. This becomes stiffer and slightly lighter in color as the depth increases. When in a dry condition large cracks are frequently seen in the soil, and if plowed when wet it bakes into very hard clods.

The Houston black clay extends in a southwesterly direction from the northeastern corner to the extreme southwestern part of the area, and this belt is only broken by the alluvial deposits of the Colorado River, which crosses near its center. It also occurs in smaller areas in all sections of the area surveyed east of the hilly portion.

The topography of the country embraced by this soil type is gently rolling. The hills are low and rounded, with wide, shallow valleys between them. The average elevation of this prairie section is about 600 feet above sea level, the highest ridges having an altitude of 675 to 700 feet. Many small streams flow through this prairie, furnishing excellent drainage for the rolling uplands. The small streams in this formation differ from those in other sections of the area in having gently sloping banks instead of flowing in deep, canyonlike gorges between perpendicular limestone walls. Very few, however, are perennial, the majority being dry most of the year.

The Houston black clay is a residual soil, and is derived from a series of calcareous clays and marls, which underlie the type to a great depth. These clay deposits are known as the Webberville and Taylor marl formations, and are light brown in color before weathering into the stiff, black prairie soil.

In many places small areas are encountered which have small, rounded gravel, one-eighth of an inch to 3 inches in diameter, scattered over the surface. These are the remains of an old gravel bed which once overlay a large proportion of this clay formation, but the areas are too few and the amount of gravel too small to affect the value of the sections where they exist.

Other small areas, known locally as "gall spots," occur at intervals in the area covered by this type. Cotton and fruit trees are the plants affected by these spots, and these suffer more during a wet than a dry season. These areas are never of great extent, and are not due to the presence of alkali, as is generally supposed.

Under ordinary conditions large yields of all the crops cultivated in the area are obtained from this soil. Cotton averages about one-half to three-fourths of a bale per acre when free from the boll weevil, but during the present season an average yield of about one-fourth of a bale per acre was realized. When well cultivated, much larger yields per acre have frequently been obtained. Corn produces on an average from 20 to 25 bushels per acre, much larger yields being obtained during a wet season, when the crop is not affected by the usual summer drought. Sorghum cane is extensively cultivated, and crops of 2 to 3 tons per acre are usually obtained, 1 to 3 cuttings each season being made. Oats are not extensively grown, and are seldom thrashed out, being produced mainly for feeding purposes, but 25 to 30 bushels per acre is considered a fair estimate of the yield of this crop.

With an average amount of rainfall during the spring months, good yields of all the crops grown are obtained on this soil, the stiff clay subsoil enabling it to withstand the hot, dry summers much better than any of the other upland types.

Potatoes and garden truck are extensively grown for home use, but no effort has been made to grow these crops on a large scale for the markets.

Limited experiments indicate that alfalfa can be grown on this soil as well as on the river bottoms, although more care is necessary in the beginning in order to get a stand.

The Houston black clay is valued at from $35 to $60 an acre, according to its location.

The following table shows the results of mechanical analyses of both soil and subsoil of this type.

Mechanical analyses of Houston black clay.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
10437	¼ mile E. of Creedmoor.	Stiff clay, 0 to 10 inches	0.7	0.8	0.7	2.7	4.7	52.2	38.1
10439	1 mile E. of Manor	Dark clay, 0 to 12 inches	.6	1.5	1.0	3.7	6.8	46.3	40.0
10441	¼ mile N. of Delvalle.	Clay, 0 to 12 inches	1.2	2.7	2.3	5.0	7.5	40.4	40.7
10440	Subsoil of 10439	Brown stiff clay, 12 to 36 inches.	.9	1.4	.9	3.8	5.8	49.4	37.6
10438	Subsoil of 10437	Brown stiff clay, 10 to 36 inches.	.4	.6	.5	1.6	4.1	53.0	39.7
10442	Subsoil of 10441	Dark stiff clay, 12 to 36 inches.	1.2	3.5	3.1	5.1	8.7	33.3	45.0

The following samples contained more than one-half per cent of calcium carbonate ($CaCO_3$): No. 10437, 1.5 per cent; No. 10438, 3.7 per cent; No. 10439, 17.5 per cent; No. 10440, 28.7 per cent: No. 10441, 11.1 per cent; No. 10442, 14.6 per cent.

HOUSTON GRAVELLY CLAY.

The Houston gravelly clay occupies a total area of about 55 square miles and occurs on the higher ridges of the rolling prairie, mostly in the southern portion of the area. The soil is a heavy dark-brown to black clay loam or clay, 0 to 12 inches deep, and contains a large amount of gravel and rounded, waterworn pebbles. These vary in size from one-eighth of an inch to 3 inches in diameter, and are scattered on the surface and embedded in the soil. The subsoil is a stiff clay of a light-brown color, which becomes stiffer as the depth increases. This contains a smaller percentage of the rounded gravel and pebbles. Occurring, as it does, only on the higher ridges, the soil is easily eroded, the clay loam being washed down into the valleys at times of heavy rainfall, leaving the gravel exposed on the surface.

The Houston gravelly clay is derived from the remains of an old gravel formation, which once rested above the clay formation underlying the rolling prairie lands. This gravel deposit has been almost entirely worn away, leaving a thin layer capping the higher ridges. This formation has become mixed with the underlying clay, forming a stiff, heavy clay loam, which contains a large percentage of gravel and rounded pebbles.

A comparatively large part of this type is under cultivation and is considered good farming land. Its worst feature is the damage necessarily incurred by farming machinery in cultivating it. A few of the highest ridges, where the gravel is deepest, are not cultivated at present. Here the soil has been eroded, leaving a deeper layer of gravel on the surface than occurs on the hillsides. These ridges are fenced off into pasture lands, and as they support a good growth of mesquite and native grasses they are well suited for grazing purposes. The crops cultivated and the average yields are as follows: Cotton, with the usual amount of preparation of soil and cultivation of crop, yields one-fourth to one-third bale per acre. Where better methods have been used and a more thorough cultivation practiced, one-half to three-fourths bale per acre has been continuously obtained. Corn yields from 20 to 25 bushels per acre, and, as is the case with this crop on the other types, it produces larger yields in a wet season. Oats yield from 30 to 40 bushels per acre when not affected by "rust," which often does great damage to this crop. Only about one-half of the oats crop is thrashed, the remainder being used as hay. Wheat is not extensively cultivated, but is often used as pasturage for sheep during the winter months. It is then cut and fed to stock. Sorghum is extensively grown, and three cuttings are usually obtained. The crop averages about 2 tons per acre. Kafir corn is also cultivated for feeding purposes with good results.

This type of soil suffers no more from the summer droughts than the other upland types, the stiff clay subsoil enabling it to preserve enough moisture for the maturing of the crops grown, although its topography and the gravelly character of the soil cause it to be more thoroughly drained than the stiffer soils on the more level prairies.

The following table shows the results of mechanical analyses of the fine earth of both soil and subsoil of this type:

Mechanical analyses of Houston gravelly clay.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10443	3 miles E. of Evelyn.	Black heavy loam, 0 to 12 inches.	0.3	0.4	0.5	2.3	8.5	48.2	39.6
10445	2 miles N. of Delvalle.	Heavy clay loam, 0 to 12 inches.	1.2	3.3	4.3	10.1	7.3	32.0	41.6
10446	Subsoil of 10445	Brown stiff clay, 12 to 36 inches.	2.1	3.8	4.0	8.4	8.9	35.1	37.7
10444	Subsoil of 10443	Dark stiff clay, 12 to 36 inches.	.7	.6	.4	2.0	7.6	48.4	40.4

The following samples contained more than one-half per cent of calcium carbonate ($CaCO_3$): No. 10444, 0.8 per cent; No. 10445, 0.8 per cent; No. 10446, 0.7 per cent.

AUSTIN CLAY.

Among the upland soils, the Austin clay ranks next to the Houston black clay in agricultural value. Having very similar topographic features, and being well drained and easily cultivated, it is often valued as highly as the stiffer clay soil. The soil to an average depth of 10 inches is a dark-brown to black loam, containing a large percentage of silt and clay. When wet it becomes stiff and tenacious, and, like the heavier clay soil, has a tendency to form into hard, brick-like clods if plowed in this condition. Small particles of partially disintegrated limestone are usually present on the surface and in the soil.

The subsoil is a dark-brown stiff clay, which immediately becomes lighter in color and more silty as depth increases, grading at 25 to 30 inches into a white silty material composed of soft, chalky limestone. This chalky material can be easily crushed between the fingers, and often extends for several feet below the surface before it becomes hard enough to offer any resistance to the roots of plants. The largest unbroken area of this type occurs northeast of Austin, and extends from near the river to the northern boundary of the survey. A much smaller area extends from the Colorado River at South Austin to Manchaca Springs.

This soil occurs on the rolling uplands between the rough, hilly country to the west and the black prairie lands. The hills are rounded, with gently sloping sides, but often have steep bluffs of white limestone along the stream courses. The streams have cut deep gorges through the soft, chalky formation underlying this soil, and though drainage in this climate is seldom necessary, they serve to carry off the excess water in times of heavy rains.

The Austin clay is easily eroded, and small areas where the underlying chalky white limestone outcrops are frequently seen on the steeper hillsides and on the summits of the rounded knobs. Deep erosions extending from the hills to the small streams are also common. These erosions are often cut down several feet into the soft, white chalky material. In an area of greater rainfall the tendency of this soil to wash and become gullied would be attended with much more serious results than it is in this area.

The soil is derived from the weathering of a soft limestone formation, known as the Austin chalk. This rock weathers rapidly, breaking up into thin, shaly layers which are soon transformed into the white, silty material which composes the greater proportion of the subsoil.

The Austin clay can not withstand droughts as well as the Houston black clay, but in a wet season it produces as large yields of cotton as any of the other upland soils, and a very large part of this soil is under cultivation, even the steeper hillsides, where much of the soil has been eroded and washed down into the valleys, making good pasture lands. The crops grown are cotton, corn, sorghum, and Johnson grass. Cotton averages about one-third of a bale per acre, but in a wet season a yield of three-fourths of a bale to 1 bale per acre has often been realized. Corn is not extensively cultivated, as it is likely to suffer from the summer droughts, but 18 to 20 bushels per acre are obtained when there is an average rainfall during the growing season. Sorghum produces about 2 tons per acre. Johnson grass is also produced for feeding purposes, 2 tons per acre being estimated as an average yield. Wheat and oats are very seldom cultivated, and are then used for pasturage or cut for feed, a very small part being thrashed out.

Small "gall spots" also occur on this type, affecting cotton and fruit, but other crops can be successfully grown on these small areas.

This soil is valued, according to its location, at from $30 to $45 an acre.

The following table shows the results of mechanical analyses of the fine earth of both soil and subsoil of this type:

Mechanical analyses of Austin clay.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10466	2 miles S. of Austin	Brown clay, 0 to 10 inches.	1.1	2.2	1.8	7.2	11.6	38.5	37.6
10462	4 miles N. of Austin.	Light brown clay, 0 to 8 inches.	1.5	3.1	2.3	7.2	12.8	35.2	37.7
10464	1¼ miles SW. of Fiskville.	Clay, 0 to 10 inches	1.6	1.9	1.6	5.3	6.5	42.0	41.2
10465	Subsoil of 10464	Calcareous clay, 10 to 36 inches.	2.7	3.8	2.5	8.0	8.4	37.8	36.6
10463	Subsoil of 10462	Calcareous clay, 8 to 36 inches.	.7	2.5	1.8	5.3	8.2	37.8	43.5
10467	Subsoil of 10466	Brown clay, 10 to 36 inches	1.9	2.7	1.8	6.1	8.6	34.3	44.6

The following samples contained more than one-half per cent of calcium carbonate ($CaCO_3$): No. 10462, 39.6 per cent; No. 10463, 69.4 per cent; No. 10464, 54.3 per cent; No. 10465, 69.3 per cent; No. 10466, 35.1 per cent; No. 10467, 57.3 per cent.

LUFKIN FINE SANDY LOAM.

The Lufkin fine sandy loam consists of a fine sandy loam, 12 inches deep, varying in color from gray to brownish red. The sand content is of medium to very fine grades. This overlies a subsoil of stiff, sticky red or brown laminated clay. This clay can be easily separated into thin layers, having very thin strata of fine sand between them. For the first few inches the subsoil has a small sand content derived from the upper soil, but it becomes very stiff and waxy as depth increases.

This soil occurs in one large, unbroken area, covering about 40 square miles in the extreme southeastern corner of the area, only a few small isolated areas being found outside of this belt. On a few of the rounded hills are found small areas, having rounded pebbles and fragments of sandstone scattered over the surface and in the soil itself, but these are of small extent and infrequent occurrence.

The Lufkin fine sandy loam occurs on a series of low, rounded hills, having a general elevation of 500 feet above sea level. It is easily eroded, and the small streams have cut deep gullies between the rounded hills.

Crops on this soil are often affected by droughts, the rolling topography and sandy nature of the soil allowing the water to be carried off by the numerous small streams, which contain water only in times of heavy rains.

This type is derived from a series of sand, sandstone, and stiff clays known as the Lytton formation. The sandstone is fine-grained and grayish in color, but when in a state of decomposition it often becomes red or brown, the color varying with the proportion of iron present. Some of the hills are capped by layers of sandstone, but only very thin strata now exist over most of the area, and these are in a state of almost complete decomposition. Small areas of the red clay subsoil are often exposed on the steeper hillsides, the sandy soil having been removed in times of heavy rainfall. A few rounded, waterworn pebbles are often embedded in the stiff red clay.

Cotton, corn, sorghum, oats, fruits, potatoes, and vegetables are grown on this type. Up to the season of 1903 cotton had averaged from one-fourth to one-third of a bale per acre, but during that season, owing to the damage done to the crop by the Mexican boll weevil, it averaged only about one-eighth to one-seventh of a bale per acre. Corn will yield 15 bushels per acre under ordinary conditions, while in a wet season 25 to 30 bushels are often produced. Sorghum is largely cultivated, and is sown broadcast. It produces about 2 tons per acre, two or three cuttings being usually obtained. Oats is an uncertain crop, and only a small acreage is devoted to it. The crop is seldom thrashed, being used mainly for feeding purposes.

There are a few small orchards on this type, which are in a flourishing condition, and almost any variety of fruit adapted to the climatic conditions seems to do exceedingly well. Potatoes, especially sweet potatoes, are very successfully grown, and cabbage and early vegetables are well adapted to this soil. A small quantity of tobacco has been grown for home use, and when the season is favorable it gives excellent results. The soil is productive and well adapted to a large variety of crops, its inability to withstand the droughts being the main difficulty in its successful cultivation. A large part of the area embraced by this soil type is covered with a thick growth of hardwood. A small scrub oak or post oak is the principal variety. The wooded sections are used for pasturage and are valued at from $4 to $6 an acre, while the cultivated lands sell for $10 to $15 an acre.

The following table shows the results of mechanical analyses of both soil and subsoil of this type:

Mechanical analyses of Lufkin fine sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
10425	1 mile S. of Cedar-creek.	Fine sandy loam, 0 to 10 inches.	0.4	0.7	0.5	15.6	59.4	15.5	7.9
10427	3 miles S. of Glass...	Very fine sandy loam, 0 to 10 inches.	.3	1.1	.7	8.9	51.8	28.5	8.2
10423	3 miles S. of Cedar-creek.	Fine sandy loam, 0 to 12 inches.	.5	1.0	.6	14.4	56.5	16.1	10.5
10424	Subsoil of 10423......	Stiff clay, 12 to 36 inches.	.4	.4	.3	7.3	33.3	19.0	39.2
10426	Subsoil of 10425......	Red stiff clay, 10 to 36 inches.	.2	.4	.2	8.5	34.5	14.6	41.2
10428	Subsoil of 10427......	Red stiff clay, 10 to 36 inches.	.4	.4	.3	2.8	22.6	25.9	47.5

COLTON STONY CLAY.

The soil of the Colton stony clay averages about 8 to 10 inches in depth, and consists of a dark-brown to reddish-brown clay or clay loam. When cultivated it becomes loose and friable, and, but for its stony nature, would be well adapted to farming. The soil contains from 40 to 60 per cent of fragments of flint and hard, honeycombed limestone. The subsoil also carries a large quantity of rock fragments of various sizes. Owing to the large proportion of stone, cultivation is impracticable over a great part of the area.

The subsoil, from 10 to 36 inches, is a stiff, dry, compact clay, becoming stiffer and slightly redder in color as the depth increases. Large rock fragments, embedded in it, are often encountered at from 20 to 30 inches, and on the steeper hills the underlying stratum of hard white limestone is encountered at a depth of from 30 to 60 inches.

The Colton stony clay extends across the northwestern section of the area, comprising about 90 square miles, and occurs also on the more level areas of the rough, hilly section, or on the flat summits of the high ridges.

The general character of the country is rough and hilly, with an average elevation of from 100 to 200 feet above the black prairie belt. The hillsides are steep and stony, large areas of Rock outcrop occurring on the steeper slopes.

There are numerous small streams, which have cut their channels to a great depth through the alternate layers of hard and soft limestone, and now flow between perpendicular limestone walls, often 50 feet or more in height.

This soil is derived mainly from the disintegration of the hard white limestone of the Edwards formation, containing interbedded strata of flint. The softer material has weathered into the stiff clay soil, leaving the fragments of flint and harder limestone scattered on the surface and through the soil.

A very small proportion of this type is under cultivation, but small, level areas occur, scattered over the area, which are comparatively free from stones, or in which the stones have been removed from the surface. These are successfully cultivated to all crops grown on any of the upland soils.

The greater part of the Colton stony clay is covered with a heavy growth of timber, post oak and live oak predominating, while the more hilly and rocky sections support a heavy growth of cedar. This rough section is devoted chiefly to pasture for stock, the largest herds of cattle in the area being found on this type of soil, and the type as a whole is better adapted to grazing than to cultivation.

Where cultivation is practicable, fair yields of cotton, corn, sorghum, and oats are obtained. Cotton averages about one-fourth bale per acre, and up to the present time the crop on this soil has been comparatively free from the boll weevil. Corn will yield from 15 to 20 bushels per acre in a season of average rainfall. Oats yield 30 bushels per acre, and wheat, though seldom grown, produces 10 to 15 bushels per acre.

The soil is well adapted to fruit and grapes, limited experiments showing that both orchards and vineyards do exceedingly well.

Its value varies with topography and location, a fair general average being about $8 an acre.

The following table shows the results of mechanical analyses of fine earth of both soil and subsoil of this type:

Mechanical analyses of Colton stony clay.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10409	7¼ miles SW. of Duval.	Brown clay, 0 to 9 inches.	0.3	0.9	0.7	3.1	6.1	55.4	34.4
10413	1 mile N. of Rutledge.	Brown stiff clay, 0 to 8 inches.	1.2	1.9	1.1	3.2	7.4	48.2	36.9
10411	2 miles W. of Duval.	....do	.8	1.8	1.1	3.2	4.5	33.9	54.4
10410	Subsoil of 10409	Red stiff clay, 9 to 30 inches.	.5	1.1	.6	3.3	7.2	54.9	32.2
10414	Subsoil of 10413	Brown clay, 8 to 36 inches.	2.4	2.8	1.4	2.8	6.4	45.0	39.0
10412	Subsoil of 10411	....do	.6	1.9	1.3	3.5	6.0	42.3	43.9

The following samples contained more than one-half per cent of calcium carbonate ($CaCO_3$); No. 10410, 3.5 per cent; No. 10412, 3 per cent; No. 10413, 3.6 per cent; No. 10414, 17.6 per cent.

YAZOO SANDY LOAM.

The Yazoo sandy loam is one of the most productive soils of the area, and is adapted to a greater diversity of crops than any of the other soil types. The soil is composed of a grayish to light-brown fine sandy loam 0 to 15 inches deep, with a large silt content. This grades into a subsoil which becomes slightly red or brown in color, and more silty as the depth increases. The subsoil is very compact, and at a depth of 4 to 6 feet contains a very small percentage of sand.

This type occupies the broad, level bottom lands on each side of the Colorado River, but has a sufficient elevation above the stream level to protect it from overflow. The topography is level, except for an occasional gentle swell and a very gradual slope toward the stream bed.

The Yazoo sandy loam covers an area of 60 square miles, and extends along the course of the Colorado River from Austin to the point where the river leaves the area. In some places the bottoms occupied by this soil are 3 or 4 miles wide.

Only once or twice since the area has been settled has the river overflowed these bottom lands, its present level being from 20 to 30 feet below them. This insures good drainage, as well as protection against floods. The river, in cutting its present channel through the deep canyons of the hills west of the area, took in suspension the silty material forming the majority of these alluvial deposits, and on reaching the more level country east of the hills deposited it along its course. Later inundations have added a layer of sand to this material, forming this productive sandy loam of the river bottoms. The light reddish-brown color of the silt deposit is seen in the limestone of the bluffs along the canyon cut by the river.

This soil can easily be irrigated, and experiments show that its productiveness is greatly increased where irrigation is practiced. Its texture makes it easy to cultivate and capable of holding a plentiful supply of water, as well as preventing it from packing when wet, or baking into hard clods.

The Yazoo sandy loam is well adapted to the cultivation of cotton, and under ordinary conditions produces one-half to three-fourths bale per acre. It is the most valuable corn soil in the area, 40 to 50 bushels per acre being ordinarily secured. Sorghum will produce from 3 to 5 tons of forage per acre, and Kafir corn is also successfully grown. Oats and wheat are seldom sown on this soil, but produce a strong, rank growth, suitable for hay, for which they are used.

Alfalfa is not at present cultivated, except on a very limited acreage, but good stands are easily obtained and large yields are realized. This soil is adapted to the production of early truck and vegetables, and to alfalfa. Large areas can be irrigated at small expense, and truck growing could be made an important industry.

The soil is very productive, and if properly cultivated much larger yields of the various crops grown could be produced. It is valued at from $40 to $60 an acre.

The following table shows the results of mechanical analyses of both soil and subsoil of this type:

Mechanical analyses of Yazoo sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
10450	1 mile N. of Montopolis.	Fine sandy loam, 0 to 10 inches.	0.5	1.9	2.5	29.8	33.7	22.8	8.8
10448	Near Webberville	Silty loam, 0 to 15 inches.	.2	.4	.5	3.0	20.5	64.6	10.7
10452	2 miles SE. of Delvalle.	Fine sandy loam, 0 to 12 inches.	2.4	11.5	9.2	22.1	22.4	16.2	16.2
10451	Subsoil of 10450	Fine sandy loam, 10 to 36 inches.	.1	.2	.2	5.8	47.5	34.6	11.5
10449	Subsoil of 10448	Silty loam, 15 to 36 inches.	.1	.3	.5	3.8	20.6	62.2	12.5
10453	Subsoil of 10452	Fine sandy loam, 12 to 36 inches.	2.6	8.4	6.3	16.6	24.4	22.1	19.6

The following samples contained more than one-half per cent of calcium carbonate ($CaCO_3$): No. 10448, 16.2 per cent; No. 10449, 16.4 per cent; No. 10450, 18.4 per cent; No. 10451, 17.4 per cent, No. 10452, 11.9 per cent; No. 10453, 12.5 per cent.

TRAVIS GRAVELLY LOAM.

The Travis gravelly loam covers an area of about 24 square miles. The soil is a coarse sandy loam containing a large amount of rounded gravel on the surface and in the soil itself. This grades, at a depth of 10 to 12 inches, into a mass of coarse sand particles and rounded gravel, the latter often being from 2 to 4 inches in diameter. The sand and gravel are cemented together by a stiff, sticky red clay.

This soil type is located on the higher ridges in the immediate vicinity of the river, and also occurs at intervals in small areas on the rolling uplands, from Austin to the eastern boundary of the area. The topography is rolling, the hills being rounded and covered with a thick growth of hardwood timber.

The material from which this soil is derived was brought down by the river at an early day and deposited along its course. At the present time this material forms a series of terraces on each side of the stream. Many of the rounded pebbles are of quartz and granite, indicating that they were transported from the hills northwest of the area.

The general characteristics of this soil make it of little agricultural value. Its location, together with its texture, causes water to seep rapidly through it to the lower levels, and as a consequence the crops suffer severely from drought. On a few of the more level areas crops are cultivated, and fair yields are often obtained during a wet season.

The crops grown and average yields per acre are as follows: Cotton, one-sixth to one-fifth bale; oats, 4 to 8 bushels; corn, 8 to 10 bushels in an average season; but corn is an uncertain crop on this soil, as it is seldom able to withstand the summer droughts.

This land is valued mainly for the timber on it, a heavy growth of post oak and black-jack oak covering a large part of the type. It is also used for pasturage for stock, a fair growth of native grasses being afforded throughout the entire year.

The Travis gravelly loam seems best adapted to melons and fruit trees. Small orchards of peach trees and other varieties of fruit suitable to this climate thrive and give excellent yields.

The following table shows the results of mechanical analyses of the fine earth of both soil and subsoil of this type:

Mechanical analyses of Travis gravelly loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10417	1 mile E. of Austin	Coarse sandy loam, 0 to 10 inches.	34.7	24.5	5.7	8.9	6.5	15.2	4.4
10415	4½ miles SE. of Manor.	Gray gravelly sand, 0 to 8 inches.	28.8	22.8	8.0	12.2	11.1	12.4	4.6
10419	2 miles NW. of Hornsby.	Gravelly sandy loam, 0 to 10 inches.	22.0	17.5	8.2	12.1	8.9	12.1	19.2
10418	Subsoil of 10417	Red stiff sandy clay, 10 to 36 inches.	19.6	21.6	6.7	9.8	5.7	13.8	22.6
10416	Subsoil of 10415	Gravelly clay, 8 to 36 inches.	18.6	13.7	3.4	5.3	5.0	11.7	42.3
10420	Subsoil of 10419	Gravelly clay, 10 to 36 inches.	12.0	13.3	7.2	7.0	5.9	8.9	45.7

YAZOO CLAY.

To a depth of 12 inches the soil of the Yazoo clay is a heavy dark-brown to black clay loam or clay, being heavier in the small, shallow depressions and more loamy on the slight elevations. The subsoil has a lighter brown color, and is very stiff and tenacious. It often contains small waterworn pebbles. The largest area of this type occurs in the valley along the course of Cedar Creek, in the southeastern part of the area, but most of the smaller streams have a narrow strip of this soil along each bank.

The Yazoo clay is an alluvial soil, occurring along the courses of most of the small streams, but seldom extending very far from their immediate banks.

These alluvial areas are comparatively level, having a gentle slope toward the stream and an occasional shallow depression or gentle swell. Its nearness to the streams, which have generally cut their channels down many feet below the level of the bottom lands, gives this type good drainage. There are no swamps or sink holes, but immediately after an overflow water often stands for some time in the lower depressions. This can be easily remedied by surface ditching to the adjacent stream.

This type is derived from material brought down by the streams in times of heavy rainfall and deposited along the flat areas in the valleys. This material consists chiefly of the black clay and silt forming the upland prairie, which is easily eroded and washed down into the small "arroyos," and thence to the streams. This soil also contains a large amount of organic matter and is very productive. Cotton, corn, oats, sorghum, and potatoes are the crops cultivated. Cotton yields from one-half to three-fourths bale per acre under ordinary conditions, but the cool, moist conditions of the bottoms seem better suited to the boll weevil than those of any other type of soil, and very small yields have been obtained in the last two seasons. For corn, 25 to 30 bushels is the average yield. A heavy, rank growth of oats is produced, giving a large quantity of straw with very little grain. Sorghum yields about 2 tons of fodder per acre, and potatoes are successfully grown, large crops being secured.

The soil is not subject to frequent overflow, as the steep banks of the streams are sufficient to protect it during any ordinary rainfall. It is considered a very good type of land for general farming purposes. Much of this soil along Cedar Creek could be very easily irrigated and cultivated to rice or alfalfa.

The following table shows the results of mechanical analyses of the fine earth of both soil and subsoil of this type:

Mechanical analyses of Yazoo clay.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10458	½ mile S. of Williams store.	Clay, 0 to 12 inches	0.1	0.3	0.5	4.6	12.6	40.1	41.7
10456	1 mile S. of Science Hall.	Clay, 0 to 10 inches	1.7	2.1	1.2	3.5	7.9	32.6	50.9
10459	Subsoil of 10458	Dark stiff clay, 12 to 36 inches.	.1	.2	.4	4.5	10.6	39.0	45.0
10457	Subsoil of 10456	Heavy clay, 10 to 36 inches	.5	1.1	.9	4.0	9.1	37.9	46.6

The following samples contained more than one-half per cent of calcium carbonate ($CaCO_3$): No. 10456, 13.4 per cent; No. 10457, 36.5 per cent; No. 10458, 1.6 per cent.

YAKIMA STONY CLAY.

The Yakima stony clay, to a depth of 10 inches, is a stiff, dark reddish-brown clay and has a large amount of rock fragments scattered on the surface and extending down into the soil and subsoil. The subsoil becomes slightly yellowish in color as the depth increases and is a stiff, sticky clay, containing a large percentage of rock fragments. These rocks are a species of basalt and are present in such large quantities as to render the land unfit for cultivation. A heavy growth of native grasses covers almost the whole extent of this type, affording excellent pasturage during the entire year.

This soil covers a very small area in the south-central part of the area surveyed. It is located on a rounded hill, known as Pilot Knob, about 7 miles south of Austin. This hill rises about 100 feet above the surrounding prairie and is the remains of an ancient volcano.

The total area embraced by this type is only about 2 square miles.

The following table shows the results of mechanical analyses of the fine earth of both soil and subsoil of this type:

Mechanical analyses of Yakima stony clay.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10431	S. of Austin	Brown heavy clay, 0 to 12 inches.	2.2	5.2	2.5	3.8	4.6	26.3	55.5
10433	S. of Austin	Brown heavy clay, 0 to 12 inches.	.2	.3	.2	.4	1.8	22.7	74.5
10432	Subsoil of 10431	Stiff heavy clay, 12 to 36 inches.	3.9	7.2	4.1	8.5	6.6	23.8	45.9
10434	Subsoil of 10433	Stiff heavy clay, 12 to 36 inches.	.1	.4	.6	2.3	3.2	21.8	71.8

ROCK OUTCROP.

The largest areas of Rock outcrop occur in the rough, hilly section west and northwest of Austin.

These hills rise to an elevation of 1,000 feet or more in a series of bare limestone terraces, which are either entirely destitute of soil or are too stony to support more than a very scrubby growth of cedar.

Large areas are often encountered on most of the higher hills, reaching from their summits to their bases, where the bare white limestone formations are exposed, the slope being too steep and the process of erosion too rapid to permit the accumulation of even a thin layer of soil.

AGRICULTURAL METHODS.

The growing of cotton has for a number of years entirely replaced extensive cattle grazing in the Austin area, and more intensive methods of cultivating this staple are coming into favor with the increased value of lands and the greater number of small farms.

The gradual loss in productivity of the soil that must result from growing one crop continuously is noticed to only a slight extent on even the oldest cultivated fields. But this fact and the recent ravages of the cotton-boll weevil are causing a recognition of the need for more diversified farming. This will make possible a rotation of crops besides adding to the income in seasons when the usually profitable returns from the cotton crop can not be obtained because of a depression in prices or an especially low yield.

Rotation of cotton with the minor crops, such as sorghum, corn, and oats, is practiced with beneficial results. The latter, however, are grown on so small a scale, comparatively speaking, that the cotton crop must usually follow itself.

In preparing for cotton the ground is plowed in ridges, which are placed about 3 feet apart on the upland soil and 4 feet on the river bottoms. The plowing is about 4½ inches deep on all the soil types, and four or five furrows with a two-horse plow form a ridge. The usual and more approved method of plowing, however, is with a double-moldboard plow, drawn by four horses or mules. Its use dispenses with that of a second plow, and saves the labor of one man, as well as considerable time, for only one trip across the field is required to make each ridge. One-third or more of the ground is turned in this operation. Those farmers who are practicing the most thorough culture of the crop precede the above ridging by making a furrow with a smaller shovel plow where the center of the ridge will lie, thus loosening up the soil over which the row is to be planted. The plowing is done during the winter months, at times when it is not too wet. Before planting the ridges are partially leveled down with a smoothing harrow or log. An improved cotton planter is used, and the seed is put in the middle of the ridge, 4 inches deep, at the rate of a half bushel per acre. The usual time of planting has been from April 1 to May 10, but the presence of the boll weevil now makes early planting important, and March 15 is not considered too soon. Earlier maturing varieties are being used to aid in escaping the weevil. Cultivation begins when the plants appear, the weeds often being destroyed at the start with a smoothing harrow. With the first hand hoeing the plants are chopped out to 16 or 18 inches apart. The two-horse cultivator is used in tending the crop, and it is recognized that shallow tillage is best, because it preserves more moisture and is less injurious to the roots.

The last plowing usually takes place when the bolls are forming. Because of the great natural productivity of the soils, commercial fertilizers have not been found profitable here. The beef and dairy animals and hogs that are kept in small numbers on most of the farms can be pastured throughout the year, so that little manure is accumulated that can be applied to cultivated fields. The practice of cutting and burning the old cotton stalks to destroy the boll weevil has grown, and during the last two years it has been carried out on a majority of the fields in the area.

Corn is planted from February 20 to March 20. The fields are usually plowed level in preparing for this crop, and the distance between the rows is 4 feet, with the stalks 2 feet apart. Level instead of ridge cultivation is usually practiced with corn. The ears are picked and cured without removing the husks, and the stalks are sometimes topped, but are generally not used.

Sorghum is grown largely for feed, it being the main fodder crop for both cattle and work animals. It is sown broadcast at the rate of 2 bushels per acre, the time of sowing ranging from April to June. From one to three cuttings are made each year, depending on the season and date of sowing. It is cut when in the milk or dough stage, and after curing is stacked for use throughout the year.

Oats and wheat, especially the former, are sown for hay and occasionally pastured during the winter, when grass is scanty. It is seldom that either crop is now grown for grain. Both these cereals are sown in the fall, and as they are removed from the ground as early as May a crop of sorghum can follow on the same field.

The fact that all classes of stock can be pastured the year round simplifies the question of winter feeding, which is much more of a problem in colder climates. Beef animals are fattened here on cotton seed, cotton-seed meal, and hulls, supplemented by corn, sorghum fodder, and pasturage. On a few farms in the area special attention is paid to the raising of hogs, and all conditions seem favorable to an extension of this industry.

As there has been no need for more fodder crops, alfalfa is hardly known in the area, but isolated fields show that it does exceedingly well on the river bottoms and fairly well on the Houston black clay. When the methods of growing it become well known here it will no doubt form an important addition to the list of crops now produced.

Truck is grown on the Yazoo sandy loam and the Austin clay with the aid of irrigation, but only for the local markets. The water to irrigate the former type is obtained from the river, and from a well for the Austin clay. The dam across the Colorado River above Austin, which was destroyed by flood in 1900, was built for the purpose of supplying water for irrigation and for the needs of the city. Its repair, which is being agitated, will make it possible to irrigate all the Yazoo sandy loam and parts of some other types of soil.

AGRICULTURAL CONDITIONS.

The area surveyed is purely an agricultural district, there being no manufactories of any importance. Austin, the only city in the area, owes its present prosperity to the productiveness of the surrounding country. There is a marked difference in the prosperity of the farmers on the different soil types of the area. Those farming the rolling prairie lands have gradually acquired wealth, and while many are still of the tenant class, all have the necessaries and comforts of life. The farmers on the stony types of soil which lie in the hilly sections are, as a rule, less prosperous. None have acquired wealth, but none are very poor, the sale of the timber which covers this section, together with their small herds of cattle, being the chief source of income. Cotton is the money crop of the area, and under ordinary conditions a sufficient yield is always obtained to keep the farming class in good financial standing. Up to the present time the effect of the Mexican boll weevil has not been felt to any great extent, as the rise in price has more than balanced the decreased yield of the crop. In some parts of the area the cotton crop suffered less from the weevil than in others, about one-half the average yield being obtained, but in the extreme southeastern section only a tenth to a sixth of the usual crop was marketed.

An entire failure of this crop, under the present system of cultivating cotton exclusively, would have a marked effect on the whole district. The city as well as the farming classes would soon be in financial straits; hence the need of greater diversification of crops. About one-third of the farmers are tenants, the lowest proportion being among the Swedish and German farmers holding the rolling black prairie land in the northeastern and southwestern parts of the area. Farms are rented both on a cash basis and on shares. For corn and sorghum $4 an acre is the usual rental, but for cotton the tenant pays from one-fourth to one-third of the crop produced. Cotton land is seldom rented for cash, because under present conditions no merchant will extend credit to cotton farmers renting for cash, the uncertainty of the crop preventing an assurance that the farmer will derive some income from the yield. The tenant commonly furnishes the seed, implements, work animals, and labor.

The farms on the Houston black clay and the Austin clay average about 200 acres each, and a large part of each farm is constantly under cultivation. The largest farms are on the Yazoo sandy loam along the river, 300 to 500 acres being the average size. Those situated on the Colton stony clay have a much smaller proportion cultivated, and though large tracts of 2,000 or 3,000 acres each are often owned by individuals, they are only held for their timber value and for the pasturage of cattle.

Labor is usually plentiful and cheap, and consists chiefly of negroes and Mexicans. Fifty to 75 cents a day and board is the usual wage, or, when hired by the month, about $18 with board. Cotton is thinned out at from 40 cents to $1 an acre, the wages depending on the condition of the field to be worked. During the cotton-picking season there is a great demand for labor, and many Mexicans come into the area from Mexico and the southwestern counties of Texas, while many negroes leave the cities for work in the rural districts. These are paid according to the amount of cotton picked, at the rate of 40 to 60 cents a hundred pounds. For scrap picking, the last thorough cleaning of the stalks before they are burned, $1 per hundred pounds picked is generally paid.

The cultivation of cotton has gradually replaced stock raising, until cotton is now the chief product of the area. It is cultivated on every farm, and in many instances is the only crop grown. At least 90 per cent of the cultivated lands are devoted to its production. As a rule, each farmer has 8 or 10 head of cattle, and in the rougher section of the area, on the stony loam type of soil, a few herds are pastured which contain 200 or 300 head. However, the greater part of the area being adapted to cotton, all the large cattle ranches in that section have been divided into cultivated fields. As a greater diversity of crops becomes necessary, on account of the yearly increase in the ravages of the boll weevil, more cattle and hogs will be raised. A few farmers are raising hogs at present, and the industry is proving very profitable, as there is a great demand for them in the adjacent markets of Fort Worth and Houston.

The farm houses on the Houston black clay are neat cottages and two-story frame dwellings, usually painted, and often containing many modern conveniences. The barns are small, as the climatic conditions do not necessitate the housing of stock during the winter, and the cotton crop is usually sold immediately after it is taken from the fields and baled. The characteristic dwellings of the western and southeastern sections are much smaller, being seldom more than a small one-story cottage, with a small shed or barn for storing feed and farming machinery.

Truck, including sweet and Irish potatoes, is grown for the local markets, but no attempt has been made to cultivate these crops for shipment out of the area. The Yazoo sandy loam is excellently adapted to truck, and with the aid of irrigation, which can be easily secured on this type, large quantities could be produced and shipped to the northern markets.

Alfalfa can be grown on both the black prairie soils and the river bottoms, but is better adapted to the latter, and when irrigated large yields are always obtained. A few experiments have demonstrated that tobacco can be grown successfully during favorable seasons on the Lufkin fine sandy loam, in the extreme southeastern section of the area. The difficulty in irrigating this type is the main hindrance to the successful production of this crop.

The Houston black clay and the Yazoo sandy loam are recognized as the best soils in the area for the production of cotton. These soils are of fine texture, and are able to withstand the summer droughts better than the sandy or more shallow soils. However, in a wet season the Lufkin fine sandy loam and the Austin clay often produce crops equal to those of the types named. The fine sandy loam of the Colorado River bottoms and the heavier loam along the small streams are the best corn soils of the area. A failure of the crop on these types is very rare, and excellent yields are realized.

Four railroads now reach the area, three of which connect it with the larger markets, both north and south. These furnish ample facilities for exporting the products of any section of the area to either the local or more distant markets. Well-kept roads lead from Austin to all the small settlements in the surrounding country, and a great many minor roads and lanes connect these with every locality. It is only just after excessive rains that these roads are difficult to travel. The level topography of the country and the dryness of the climate make it easy to keep all classes of roads in the area in excellent condition. Two large steel bridges over the Colorado River, together with a number of fords and ferries, enable the farmers of the southern half of the area to reach the local market. Austin is the market for almost all the products of the area. The cotton is first sold in the local market, but eventually goes to Galveston or New Orleans. Fort Worth and Houston have large packing houses, which furnish a ready market for all hogs and cattle shipped from the area. The large dairy farms in the immediate vicinity of Austin find a ready market for their produce in that city, and the demand for vegetables by the local canning factory can not be supplied from the small acreage cultivated at present in the surrounding country. There is now a tendency among the cotton planters of the area, on the recommendation of the Bureau of Entomology of this Department, to grow the early maturing varieties of cotton, and many experiments are being carried on with seed from Georgia and other more northern States. The introduction of these varieties, together with a more thorough cultivation and early planting, has for its object the largest possible production before the most destructive work of the boll weevil begins. The number of weevils increases rapidly as the crop matures, and the early maturing varieties give the larger yields. The large area of cultivable lands and the seemingly permanent productivity of the soil form a substantial basis for the general prosperity of the area—a prosperity evidenced on every hand by the neatly kept farm buildings and general business activity.

SOIL SURVEY OF THE SAN ANTONIO AREA, TEXAS.

By THOMAS A. CAINE and W. S. LYMAN.

LOCATION AND BOUNDARIES OF THE AREA.

The San Antonio area is situated in Bexar County, which lies in southwestern Texas, about 125 miles northwest of the Gulf of Mexico and about the same distance northeast of the Rio Grande. The area includes 310,016 acres, or approximately 484 square miles, in the

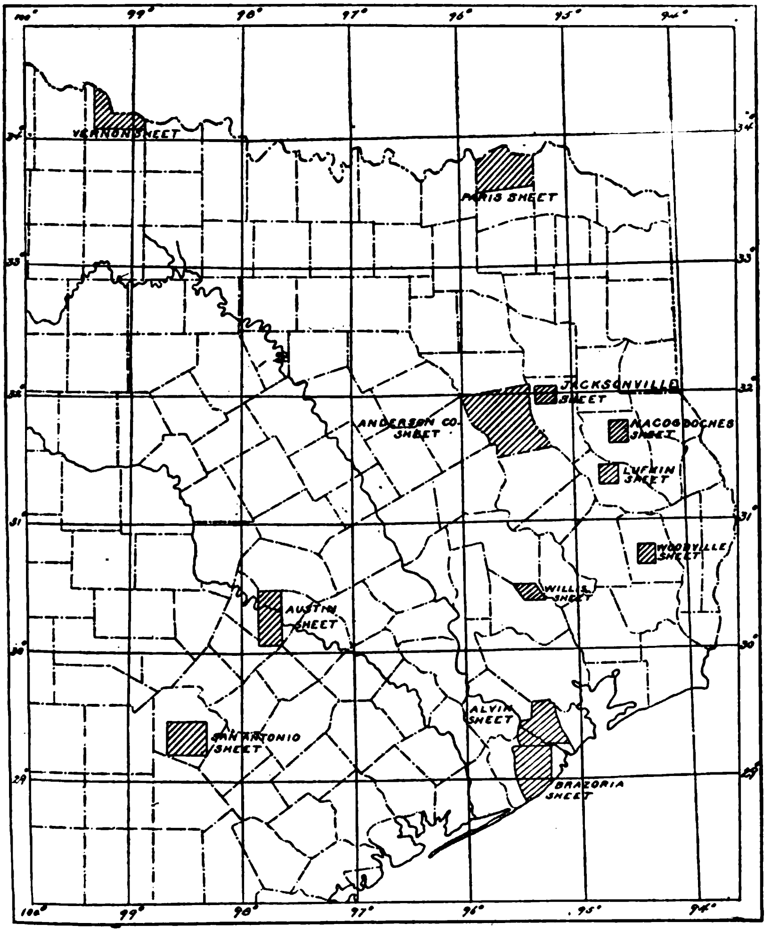

FIG. 18.—Sketch map showing location of the San Antonio area, Texas.

southern part of the county, or a little more than one-third of the entire area of the county. San Antonio, the chief town and a railroad center, is situated in the northern part of the area surveyed, and a number of other towns, the most important of which are Elmendorf and Macdona, lie within the area.

The area is comprised between meridians 98° 17′ 30″ and 98° 41′ 30″ west longitude and parallels 29° 12′ 30″ and 29° 30′ north latitude.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The first settlements in this area were made in 1716 by missionaries sent out by the Spanish Government. Missions were established south of the present city of San Antonio, and farming was instituted by means of irrigation from the San Antonio River.

In 1734 the town of San Antonio received its first charter. From this time until the beginning of the nineteenth century the progress of the colony was slow, owing to Indian hostilities and inefficient government. There had gradually developed, however, a considerable trade with New Orleans, via the Red River, and with the northern provinces of Mexico. Americans began to come in, and, though not permitted at first to acquire title to property, "squatted" in large numbers. In 1820 official permission was secured to establish an American colony, and as a result immigration of this class was largely increased.

In 1836 the independence of Texas was declared, and nine years later it was admitted as a State of the American Union. Since that time the region around San Antonio has steadily increased in population and wealth.

The earlier surveys divided this part of the State into large tracts of land, generally adjoining streams of water. The chief industry at that time was stock raising, the stock being branded and allowed to run at large. The country was chiefly a prairie, covered with a luxuriant growth of native grasses, but the sod was in time destroyed by continued feeding and trampling, and mesquite bushes have since covered the ground. Some crops were grown with the aid of irrigation.

The area suffered very little from the effects of the civil war, being removed from the region of actual conflict.

In 1877 the Galveston, Houston and San Antonio Railroad reached the area and proved a strong stimulus to progress and agricultural development. Other railways now traverse the area in all directions. Another circumstance which has aided materially in the progress of the area is its popularity as a winter resort, due to its healthful climate, pure spring water, and historic associations. This has attracted large numbers of visitors, chiefly from the North, East, and West, and many of these have remained and invested in city or country property, with the result that real estate values have increased throughout the area. They have become so high that it is no longer profitable to carry on ranching in the old way, and the larger tracts have been cut up, fenced, and devoted to farming, particular attention being paid to truck and fruit growing. In the region south and southwest of San Antonio water for irrigating purposes can be obtained by drilling artesian wells, and the increased water supply has resulted in the use of better methods and the cultivation of larger areas than heretofore.

CLIMATE.

The area lies in the semiarid region of the Southwest. Farther west the climate becomes arid, while immediately to the northeast it becomes subhumid or humid. The characteristic plants of the area, such as the mesquite, the huisache, the guaxillo, and the napol, the post oak, black-jack oak, live oak, and hickory, are all such as would naturally be found in a region lying midway between arid and subhumid conditions.

Farming can be carried on at all seasons of the year, and in favorable years two or three crops are sometimes grown. On the truck farms vegetables grow during the entire year.

Occasionally there is a frost as late as April, which kills peaches and plums.

One of the familiar experiences of winter months is the "norther." A cold wave, often accompanied by high wind, comes down from the Middle West, causing almost immediately a great fall in temperature. The summers are warm, but not disagreeably so, as the nights are always cool.

PHYSIOGRAPHY AND GEOLOGY.

Three different geological periods are represented in the area: The Cretaceous, the Tertiary, and the Pleistocene.

The Cretaceous is the oldest and underlies the others. Both the upper and lower divisions of the Cretaceous occur, but the former is better represented, as it underlies so large a portion of the Rio Grande Plain. The rocks of the Upper Cretaceous are composed of pure white limestone and chalk and the former is so soft that it is cut or sawed into blocks for building purposes. When dried it becomes quite hard and durable. The residual soils from these rocks are deep, black, and waxy. The Lower Cretaceous rocks are much harder and contain considerable quartz. As a result of the slowness with which it weathers, the Lower Cretaceous region stands at a greater elevation than the Upper Cretaceous and forms the "mountains" on the western border of the area. When compared with the "mountains," the Upper Cretaceous region, or Rio Grande Plain, is characterized by its low relief, though its surface is broken by undulations and water courses, and in places there are hills of considerable height.

The lowest beds of the Tertiary are represented in the southern and southeastern parts of the area, where they overlap the Upper Cretaceous. The Tertiary is characterized by ferruginous sands, sandy clays, and impure marls. There are also some small lignite beds. The underlying grayish-yellow sand rock is sometimes exposed on the hillsides and in the road cuts by erosion. This region is not so level as the Cretaceous immediately to the westward, and in places it is badly cut up by erosion. On the hilltops, which are sometimes quite broad and level and where the eroson is least, the deep sandy type, Orangeburg fine sand, occurs. Farther down, where the soil has been removed by erosion and the sandy clay subsoil exposed, the material was classified as Orangeburg clay.

The Pleistocene occurs as a superficial deposit of flint gravel, with some limestone gravel, both of which are embedded in a matrix of chalky material. The gravel is frequently cemented by the chalky matrix into a firm conglomerate. Most of the materials are derived from the decay of the hard limestone of the Lower Cretaceous found in the hills just west of the area. This material has been spread out like a mantle over the lower plains. The thickness of the deposit depends upon the irregularities of the surface which it overlies; sometimes it is a thin veneering upon the underlying Cretaceous lime rock, and sometimes it is 50 feet deep. This formation is typically developed on the hills in the eastern part of the city of San Antonio and on the Seguin road southwest of Converse. Another typical occurrence is on the Frio City road south of Leon Creek. In places where the underlying porous gravel comes within 20 inches of the surface this formation gives rise to the Houston gravelly clay. In places where the underlying gravel is more than 20 inches below the surface, and where the chalky material is proportionately greater and has weathered into a black, clayey material resembling the residual soils of the Upper Cretaceous beds, the soil derived is either the Houston black clay or the Houston black clay loam, depending upon the texture of the soil and subsoil.

The drainage of the area is toward the southeast, and all the water is carried by the San Antonio River and its tributaries. The lowest point in the area is on the Medina River south of Elmendorf, where the elevation above sea level is approximately 400 feet. The highest point is northwest of San Antonio, on the limestone hills which rise above Culebra Creek, where the altitude is approximately 900 feet. Hence the range in elevation throughout the area is about 500 feet.

From Elmendorf northwest toward San Antonio the rise is a gradual one, but from San Antonio northwest the surface becomes hilly, owing to a zone of faults which crosses the area near San Antonio in a northeast and southwest direction. The fault zone seems to consist of a number of parallel faults, the sum of which represents a downthrow of 200 feet or more. This zone of faulting, together with the superficial deposit which has covered the older formations in the vicinity of San Antonio, has added to the complexity of the geology around the city. It is also due to the faulting that the artesian basin ends so abruptly west of San Antonio.[a]

SOILS.

There were found and mapped in the San Antonio area twelve distinct soil types. The area and proportionate extent of each type appear in the table given below.

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Houston black clay loam	54,272	17.5	Austin fine sandy loam	21,440	6.9
Houston gravelly clay	53,696	17.3	Colton stony clay	16,768	5.4
Orangeburg fine sand	33,736	11.9	Portsmouth sandy loam	15,488	5.0
San Antonio clay loam	28,608	9.2	Austin clay	4,480	1.4
Orangeburg clay	27,520	8.9	Norfolk sand	3,904	1.3
Norfolk silt loam	24,128	7.8	Total	310,016	
Houston black clay	22,976	7.4			

HOUSTON GRAVELLY CLAY.

The Houston gravelly clay is a brownish to black gravelly clay, varying in depth from a few inches to 2 feet, but with an average depth of about 20 inches. Below this is a porous mass of quartz gravel, each fragment about the size of an egg or larger. The thickness of this gravel varies from about 10 inches to several feet, but the average is about 3 feet. Below the gravel is an unconsolidated white limestone, of unknown thickness, which is locally known as adobe and which is so friable that it can be shoveled like flour. This material is often exposed in the road cuts, and in the northwestern part of the area it comes so near the surface as to give the soil a whitish color.

The Houston gravelly clay is confined to the limestone portion of the area, and is found typically developed in the eastern part of the city of San Antonio, and also in the northeastern corner of the area, 10 miles from San Antonio. It is also found in the region between Leon Creek and the Medina River.

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[a] Much of the matter contained in this chapter was taken from the Eighteenth Annual Report of the U. S. Geological Survey.

This soil is residual, being derived from the weathering of the underlying limestone. The presence of the gravel is due to an accumulation near the surface of quartz particles, which were originally scattered through the rock mass, and which, being too heavy to be removed by rain wash, and extremely insoluble, have remained behind, while the finer and soluble parts of the rock have been removed in solution or in suspension. A few feet of gravel may thus represent the residuum from 100 feet of the rock.

Owing to the resistant nature of the quartz gravel the areas occupied by this type stand at a higher level than the surrounding country, and this fact, together with the porosity of the subsoil, renders the drainage excellent.

Less than 1 per cent of the area occupied by this type is under cultivation. Owing to the porous nature of the subsoil and the hilly surface, irrigation is usually impracticable, and at present the type is for the most part covered with mesquite and cactus and is used almost exclusively for pasturage.

There is a considerable variation in texture in different areas of this type, but its value is too low to justify recognition of its two principal phases as distinct types. In its less typical phase, where the underlying gravel is exposed, it is absolutely worthless, even for pasture. In its more typical phase, where there is a foot or more of black loam above the gravel, it supports a good growth of native grass and makes excellent pasturage, and in the valleys, as well as on some level spots, where this phase occurs, cotton and corn are grown quite successfully during wet seasons. Cotton has been known to yield 1 bale and corn 40 bushels per acre in the most favorable seasons.

The following table gives mechanical analyses of the fine earth of this soil type:

Mechqnical analyses of Houston gravelly clay.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10538	8 miles NE. of San Antonio.	Black clay loam, 0 to 12 inches.	0.5	0.9	0.4	6.4	17.9	41.8	32.0
10540	6¼ miles NW. of San Antonio.	Black heavy clay, 0 to 6 inches.	.4	.9	.8	2.5	5.0	44.8	45.6
10539	Subsoil of 10538	Black clay, 12 to 20 inches.	.6	1.5	.7	7.0	15.4	34.5	40.3
10541	Subsoil of 10540	Clay and gravel, 6 to 30 inches.	.5	1.1	.7	2.6	4.8	45.5	44.8

The following samples contained more than one-half per cent of calcium carbonate ($CaCO_3$): No. 10538, 6.1 per cent; No. 10539, 3.1 per cent; No. 10540, 0.6 per cent; No. 10541, 6.6 per cent.

HOUSTON BLACK CLAY.

The soil of the Houston black clay is a heavy clay, with an average depth of about 7 inches, varying in color from grayish brown to black. The subsoil to 36 inches and more is of about the same texture as the soil, but is a little more compact and of a lighter color.

When dry and properly handled the soil is friable and easily worked, but when wet it becomes very sticky and gummy, resembling the "gumbo" of the Red River Valley of the North. This soil is bored with great difficulty, and when the dry borings are pressed between the fingers the material is found to be hard and compact, while with the Houston black clay loam the material crumbles and has a granular appearance and feel. In its typical phase both soil and subsoil are free from gravel and rock fragments of any kind, but in the present area there is a phase which is closely related to the better phase of the Houston gravelly clay, where gravel occurs at a depth ranging from 4 to 7 feet. In such areas there are strewn upon the surface and disseminated through both soil and subsoil fragments of quartz varying in size from a pea to pieces 3 or 4 inches in diameter.

The type is confined to the limestone portion of the area, and is found typically developed in the region between Salado and Rosillo creeks. In its less typical phase it is found in spots along the San Antonio River in the vicinity of San Antonio, and west and southwest of the city.

The Houston black clay is a residual soil, formed from the slow, even weathering of white limestone belonging to the Upper Cretaceous, and because this limestone weathers so evenly the typical areas of this soil are flat and poorly drained. This feature of poor drainage has given rise to the "hog-wallow" characteristic of the soil. These "hog wallows" are depressions varying in depth from 6 to 20 inches, with a diameter of 3 or 4 feet. They occur at intervals of about 25 feet, and are accounted for by the fact that in dry weather the soil bakes and cracks. Where the cracks cross the surface material rattles down, forming a slight depression. During a rain water collects in these depressions and causes the clay to swell and expand laterally. This process, repeated through long periods of time, forms very noticeable depressions.

Owing to the semiarid condition of the area and the "droughty" nature, or lack of capillarity, of the soil only about 1 per cent of this type is under cultivation. It is largely covered with mesquite and supports an excellent growth of native grass. It is beyond question the best type in the area for pasturage, and is owned in large tracts, nearly all fenced for pasture.

The Houston black clay is one of the strongest and most important soil types in the State. In the northern counties, where conditions of rainfall are more favorable, this type has contributed largely to the prosperity of the farming class and of the neighboring cities. Under the most favorable conditions it will easily produce 1 bale of cotton or 50 bushels of corn per acre. In Lamar County it has an average value of $50 an acre for the production of these two crops. In the San Antonio area very little use has been made of the type, and then only by means of irrigation. A limited area is irrigated at present in the vicinity of San Antonio.

The following table shows the texture of typical samples of this soil:

Mechanical analyses of Houston black clay.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10551	5 miles NE. of San Antonio.	Black stiff clay, 0 to 8 inches.	0.3	0.4	0.6	7.8	11.8	44.4	34.7
10549	San Antonio	Stiff clay, 0 to 6 inches	.3	.6	.7	14.2	15.4	30.6	38.3
10552	Subsoil of 10551	Clay, 8 to 40 inches	.1	.4	.5	6.0	10.9	45.8	36.3
10550	Subsoil of 10549	Clay, 6 to 30 inches	.6	.8	.6	12.2	14.2	27.3	44.3

The following samples contained more than one-half per cent of calcium carbonate ($CaCO_3$): No. 10549, 3.1 per cent; No. 10550, 4 per cent; No. 10551, 3.4 per cent; No. 10552, 3 per cent.

HOUSTON BLACK CLAY LOAM.

The soil of the Houston black clay loam is a heavy grayish-brown to dark-brown loam or clay loam. The depth of the soil varies from 8 to 15 inches, with an average of about 10 inches. The subsoil has the same texture, but the color changes gradually from brownish gray to yellowish at a depth of 4 or 5 feet, and becomes still yellower at a greater depth. Usually a few small rock fragments are seen scattered upon the surface, and are found disseminated throughout both soil and subsoil, but where the development is typical the underlying rock is found at a great depth and fragments are absent.

The Houston black clay loam is a friable, easily worked soil. It retains moisture well, and in times of drought gives it up to the plants. These features, together with its productiveness, make it a most desirable type, especially under the semiarid conditions which exist in the San Antonio area. About 50 per cent of the type is under cultivation, while farther north, outside the area, where the conditions of rainfall are more favorable, about 95 per cent of it is cultivated, principally to cotton and corn.

This soil is found in all parts of the portion of the area underlain by limestone, but is most typically developed and occurs in the largest bodies on the gently rolling prairies. It is closely associated with the Houston black clay, but differs from the latter in that it is not so stiff and waxy. The distinction is very evident in a semiarid climate. Owing to the inability of the Houston black clay to give up moisture in times of drought it is permitted to grow up to mesquite and is used almost exclusively for pasture, while adjoining areas of Houston black clay loam are usually cleared and under cultivation. The Houston black clay loam is sometimes found in higher locations, as, for example, on the foothills and in the valleys between the gravel ridges of Pleistocene age.

In its most typical phase it is a residual soil, derived from the weathering of white limestone. It is also found in the valleys, having been carried down by rain wash, or, in some instances, redeposited along streams.

Owing to the porosity of both soil and subsoil the drainage features are excellent. The crops usually grown are cotton, corn, and sorghum, the latter for forage. The soil is naturally productive, and when irrigated it is also well adapted to truck farming and to growing such fruit as can be produced in the region. In a favorable year the average yield of cotton per acre is two-thirds of a bale, while corn yields about 30 bushels. Sorghum fodder generally yields 3 tons for the season, while the native prairie grass produces an average of 1 ton of hay per acre.

The following table shows the texture of the soil and subsoil of this type:

Mechanical analyses of Houston black clay loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10574	3 miles N. of San Antonio.	Brown loam, 0 to 12 inches.	0.3	0.6	0.8	12.1	17.1	42.5	26.6
10576	2 miles W. of San Antonio.	Clay loam, 0 to 14 inches.	.3	.5	.4	4.3	13.6	51.4	29.3
10577	Subsoil of 10576	Clay loam, 14 to 36 inches.	.5	.8	.4	8.8	15.2	43.1	30,9
10575	Subsoil of 10574	Brown clay loam, 12 to 36 inches.	.6	1.2	.9	12.8	16.7	34.8	33.1

The following samples contained more than one-half per cent of calcium carbonate ($CaCO_3$): No. 10574, 1.6 per cent; No. 10575, 8.6 per cent; No. 10576, 6.6 per cent; No. 10577, 4.9 per cent.

NORFOLK SAND.

The Norfolk sand is a coarse to medium sand, varying in color from brownish gray to gray, and having an average depth of about

10 inches, underlain by a sand of the same texture, but lighter colored, owing to its lower content of organic matter. The depth of the subsoil is usually very great, but occasionally, in limited areas, at a depth of 3 or 4 feet it becomes yellowish in color and of a sandy clay nature.

The Norfolk sand occurs only in small areas in the southeastern and southern parts of the survey, but a few miles farther south it is found in a wide belt, extending in a northeast and southwest direction and following approximately the shore line of the old Tertiary sea. It represents the coarser material carried into this sea by inflowing streams and dropped along the shore, where it was ground up by wave action and piled into beaches. In some cases the finer particles were afterwards blown into sand dunes by the wind. The fine to medium quartz material of which the type is almost entirely composed represents one stage in the reduction of rock fragments from gravel to clay. The particles which were reduced to very fine sand, silt, and clay were either carried away in suspension and deposited in deep, quiet water far from shore, or were deposited in the quiet water of the lagoons along the shore. The occurrence of this lagoon-deposited material and its special adaptation to pottery purposes account for the large and prospering pottery and tile industries in the vicinity of Elmendorf.

Approaching the region from the north the country occupied by the Norfolk sand appears as a series of abrupt hills, which represent the wind-blown material near the ancient shore. After passing over these hills to the southward the region becomes undulating and slopes gradually toward the southeast. Owing to this gradually sloping and gently undulating surface, together with the natural looseness of the soil and subsoil, the drainage features are excellent.

Under present semiarid conditions the areas occupied by this type are almost worthless for farming purposes, and probably less than 1 per cent of the type is under cultivation. Occasionally, in a wet year, the low, flat portions of the type are utilized for watermelons and cantaloupes, and the results are sometimes astonishing. The soil is naturally productive for truck farming, if water for irrigation could be secured. The characteristic growth is scrub black-jack oak and hickory, and the occurrence of the former has given rise to the local term " black-jack land." Besides the scrub forests, the soil supports only a very scanty growth of grass. Land of this type of soil has an average value of $2.50 an acre.

The table on the following page shows the texture of typical samples of this soil.

Mechanical analyses of Norfolk sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10566	Elmendorf	Gray sand, 0 to 10 inches.	0.1	2.3	9.9	60.3	18.3	6.6	2.6
10564	1 mile SW. of Bexar	Gray medium sand, 0 to 10 inches.	.6	12.9	23.6	39.1	13.6	6.8	3.1
10565	Subsoil of 10564	White sand, 10 to 36 inches.	.6	13.7	24.4	39.2	11.9	7.3	2.9
10567	Subsoil of 10566	Gray sand, 10 to 40 inches.	.1	2.5	11.4	58.3	18.5	6.1	3.0

NORFOLK SILT LOAM.

The soil of the Norfolk silt loam is a loam of medium texture, and has an average depth of from 6 to 8 inches. When dry it is yellowish brown to dark brown in color, but when wet it appears much darker. The plowed fields show that the type is sometimes marked by yellowish-brown and dark-brown spots, usually a rod or more across. The subsoil from 6 to 36 inches is brownish to brownish yellow in color, and is usually a little looser and lighter in texture than the soil. The subsoil gradually becomes yellower in lower depths, and is sometimes quite yellow at about 5 feet below the surface.

The Norfolk silt loam occurs as a belt about 4 miles wide in the southeastern part of the area, and separates the types derived from the Cretaceous limestones from those derived from the Tertiary sandstones. It is typically developed on the east side of Rosillo Creek, 10 miles southeast of San Antonio.

It is a residual soil, derived from a yellowish sandstone, a little more argillaceous in character than that occurring farther to the eastward, which weathers into the Orangeburg fine sand and Orangeburg clay.

The surface of the region where this type occurs is very much broken and eroded. The soil and subsoil seem to be comparatively free from rock fragments, but the crests of the hills and the hillsides are often strewn with red and yellow gravel, the harder parts of the sandstone, left behind in the process of weathering. Large bowlders of the underlying rock are often seen outcropping along the roads.

Owing to the broken and eroded surface of the Norfolk silt loam the rain water is carried off through the depressions and ravines to lower levels, comparatively little being absorbed by the soil. The presence of numerous small rock fragments and fine gravel increases the destructive work of erosion. Owing to these conditions the type is one of the least desirable in the area, and only about 2 per cent of it is under cultivation. Some of the remainder is so poor that it has never been fenced for pasture. In the vicinity of Martinez, east of San Antonio, where the type occurs in level tracts, and is somewhat mixed with Orangeburg clay, it is cultivated to some extent for cotton and corn, and fair crops are obtained in the most favorable seasons.

The following table gives mechanical analyses of the fine earth of typical samples of the soil and subsoil of this type:

Mechanical analyses of Norfolk silt loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct*
10572	4½ miles SE. of San Antonio.	Brown loam, 0 to 6 inches.	0.4	0.9	0.6	11.7	23.1	48.3	15.1
10573	Subsoil of 10572	Yellow loam, 6 to 36 inches.	.4	.5	.5	9.6	26.0	36.3	26.7

The following samples contained more than one-half per cent of calcium carbonate ($CaCO_3$): No. 10572, 4 per cent; No. 10573, 6 per cent.

ORANGEBURG FINE SAND.

The soil of the Orangeburg fine sand is a brownish-red to grayish-red fine to medium sandy loam, with an average depth of 2 feet. It is underlain by a red and sometimes yellowish sandy clay to a depth of 40 inches or more.

The type is a residual soil, derived from the weathering of the unconsolidated material of late Cretaceous and early Tertiary time. In the lower depths of the subsoil the sandy clay represents the material as originally deposited. The surface soil has since been more or less modified by rain wash, a part of the finer particles, such as silt and clay, having been carried away in suspension by the surface drainage waters and a part washed to lower depths in the soil by percolating water.

This type is found on the undulating and flat tops of hills and ridges in the southern and southeastern parts of the area, between the "black-jack" belt on the south and the limestone region on the north. Its location on the tops of hills and ridges is due to the fact that under the conditions of scanty rainfall which exist in the region these are the areas least subject to erosion. Farther down on the hillsides, where the erosion is greater, the soil has been removed, exposing the subsoil, and these areas were mapped as Orangeburg clay.

Owing to its location the type has good drainage. The power of the soil to absorb falling moisture, and that of the sandy clay subsoil to retain it, place it among the best types of the area for cotton, corn, fruits, and vegetables. About 75 per cent of the area of this type is under cultivation. It is easily worked, and can usually be cultivated regardless of the state of moisture. In a good year cotton will average half a bale, and some fields yield as high as 1 bale per acre. The average yield of corn is about 35 bushels. The type is well adapted to peaches and plums, but as yet there are not very many large orchards. In the vicinity of Senior some tomatoes are grown, and are marketed at San Antonio. The supply of tomatoes has already outgrown local demands, and it will not be long until canning factories are established. The type is especially well adapted to melons and cantaloupes, and many carloads are shipped annually from Elmendorf.

The following table gives mechanical analyses of typical samples of the soil and subsoil of the Orangeburg fine sand:

Mechanical analyses of Orangeburg fine sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
10568	1 mile N. of Senior ..	Fine sandy loam, 0 to 12 inches.	0.1	0.2	0.2	37.2	35.8	14.2	12.1
10570	1 mile NW. of Elmendorf.	Fine sandy loam, 0 to 20 inches.	.6	.6	.7	45.8	21.1	15.0	16.1
10571	Subsoil of 10570	Sandy clay, 20 to 40 inches.	.3	.7	.7	35.0	42.0	13.9	7.5
10569	Subsoil of 10568	Red sandy clay, 12 to 36 inches.	.6	.5	.2	31.5	34.9	16.8	15.4

ORANGEBURG CLAY.

The Orangeburg clay is a heavy red sandy loam or red clay loam, with an average depth of 15 inches, underlain by a red sandy clay, very similar in texture, but a little more compact. The subsoil often has some yellow material mixed with the red.

The Orangeburg clay is confined to the sandy region in the southern part of the area and is closely associated with the Orangeburg fine sand. South of Macdona it is found typically developed on the ridge which rises above the Austin fine sandy loam. From this locality the areas of the type extend eastward to Losoya. Beyond that place the areas are found north of the Medina River, extending in a disconnected belt in a northeastern direction and leaving the area about 10 miles east of San Antonio.

This type is a residual soil, derived from the same formation as the Orangeburg fine sand, but it has been more subject to the agencies of erosion, with the result that its texture and composition are more like the subsoil than the soil of the Orangeburg fine sand. The brownish-yellow sandstone which underlies the latter type at so great a depth as to be very seldom exposed is often exposed in the road cuts and on the hillsides of the type under discussion.

The Orangeburg clay is found on the crests of narrow ridges, on the slopes of hills, and in large, rolling areas where the sand has been removed by rain wash. Its drainage features are excellent in most places. In some of the more level and gently undulating areas the soil is so impervious to water that little is absorbed, even after a copious rainfall. Such areas are very unproductive, and support only a scanty growth of mesquite or cactus. The characteristic plant in such places is the guyean or Mexican soap plant. One phase of the type, which is extensively developed in the vicinity of Losoya, and also near Martinez, 8 miles east of San Antonio, is more loamy and absorbs moisture well. In ordinary years this phase produces fair crops of cotton and corn, and near Losoya a large peach orchard has been set out. The trees are watered every few days by going through the field with a tank. Nothing definite can be said of the undertaking as yet, as it has been under way only a short time.

About 5 per cent of the Orangeburg clay is under cultivation to cotton, corn, and sorghum fodder. In its original state it is not very satisfactory as a pasture land, because it is so "droughty" that the grass "burns" out. It is a fairly productive soil, and under favorable conditions of rainfall would be a satisfactory type for agriculture.

The following table gives mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Orangeburg clay.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10559	8 miles E. of San Antonio.	Red fine sandy loam, 0 to 4 inches.	0.5	0.4	0.6	22.8	47.4	23.3	5.1
10557	Elmendorf	Loam to clay loam, 0 to 8 inches.	1.9	.9	.5	27.2	26.5	19.2	23.7
10594	Subsoil of 10559	Red sandy clay, 4 to 36 inches.	.8	.8	.3	18.6	25.7	25.6	28.4
10558	Subsoil of 10557	Red sandy clay, 8 to 30 inches.	1.8	1.4	.7	19.7	18.2	24.0	34.0

AUSTIN FINE SANDY LOAM.

The soil of the Austin fine sandy loam is a brownish-yellow or reddish-gray fine sandy loam. There is no marked difference in texture between the soil and subsoil, and the latter, as shown along the steep river bluffs, often extends to a depth of 40 feet without change. From the surface to a depth of about 3 feet the color gradually becomes lighter. In the plowed fields typically light-colored soil is often broken with black and yellow patches, the former color being due to the slight depressions in the surface and the consequent accumulation of moisture and organic matter—the latter to outcropping of the subsoil. At about 10 feet below the surface the characteristic color of the material as shown in the river bluffs is grayish-yellow. Through the material occur many shells, and the soil is known locally as "shelly land."

This soil is found in a strip varying in width from 1 to 3 miles, extending across the southern part of the area and following the course of the Medina River. A less typical development occurs along the course of some of the larger tributaries of that river.

The type is of sedimentary origin, having been formed by the annual overflow of the streams when their channels stood at a higher level. The surface of the type is very level—almost flat in most places—and elevated from 40 to 60 feet above the present level of the streams. These streams generally have deep, narrow, winding channels, but in some places their valleys widen out, forming first bottom land, subject to annual overflow. The level tops of the bluffs are known as "second bottoms." Next to the bluffs the inflowing rain wash has in some instances cut deep arroyos and subterranean passages. The formation of this type of soil probably dates back to the Tertiary period, when the area occupied by it was an estuary, which in later years gradually filled with sediment.

This type readily absorbs the falling rains, and the drainage is very good. In a dry season it is inclined to be a little droughty, as the soil does not retain moisture so well as some of the heavier types. This condition is quite noticeable at times; and it can be seen that the "black spots" already referred to support a heavier growth of cotton and corn, chiefly because they receive more moisture and retain it better than other parts of the type.

The Austin fine sandy loam is one of the most satisfactory types in the area, and about 60 per cent of it has at one time or another been under cultivation. Some small irrigation plants have been started, the water from the Medina River being pumped to the higher levels. Some of the plants use steam and others gasoline. In a wet season it is not necessary to irrigate at all. The success of irrigation on this type has not been so great as with that carried on by means of artesian water on the San Antonio clay loam, nearer the city of San Antonio, but the difference is largely due to greater distances from market and the greater expense of installing a pumping plant. The texture and level surface of the Austin fine sandy loam make it an ideal type for irrigation, if there were a ready outlet for the products grown and if the expense of installing and operating the plants could be reduced.

The Austin fine sandy loam was one of the first types occupied by the early settlers, largely because of its river-front advantages for stock. At present cotton, corn, fruit, and some vegetables are grown. In a good season cotton will yield from one-half to 1 bale per acre and corn about 35 bushels. An excellent peach orchard is growing on the "first bottom," in the vicinity of Macdona. Considerable sorghum fodder also is grown upon "first-bottom" areas, and under ordinary conditions alfalfa would also produce abundant crops.

The following table gives mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Austin fine sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
10562	2 miles SW. of Elmendorf.	Brown fine sandy loam, 0 to 12 inches.	0.1	0.7	2.1	32.7	24.8	26.0	13.6
10563	Subsoil of 10562	Fine sandy loam 12 to 40 inches.	.1	.8	2.1	28.5	22.5	31.2	14.7

The following samples contained more than one-half per cent of calcium carbonate ($CaCO_3$): No. 10562, 47 per cent; No. 10563, 52 per cent.

AUSTIN CLAY.

The soil of the Austin clay is a light-brown to gray clay, varying in depth from 5 to 20 inches, with an average depth of about 10 or 12 inches. This is underlain to unknown depths by an unconsolidated, white chalky or floury material known locally as "adobe." Fragments of this limestone are sometimes found scattered upon the surface and disseminated throughout the soil and subsoil.

The Austin clay is found typically developed on the tops and slopes of the highest hills in the area, about 8 miles northwest of San Antonio. It is a residual soil, derived from the slow, unequal weathering of an impure white chalk of the Upper Cretaceous. Because of slowness in weathering, the areas occupied by this soil lie at a higher elevation than the surrounding country, and the characteristic topography is a succession of hills with long, even slopes. The drainage is very good, although, considering its location and drainage features, the soil retains moisture exceedingly well. It is sometimes spoken of as a "cool soil," and its white color may have some effect in regulating the soil temperature and thus indirectly the moisture supply. These features combine to make it very desirable for hay and pasturage. It is said to produce a better quality of "sage-grass" hay than any other type in the area. In favorable years it also produces fair crops of cotton and corn. The average yield of wild hay is from two-thirds of a ton to 1 ton per acre.

The following table shows the texture of typical samples of the soil and subsoil of this type:

Mechanical analyses of Austin clay.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10532	5 miles NW. of San Antonio.	Brown loam, 0 to 18 inches	0.4	0.8	0.4	3.5	12.8	44.6	37.8
10534	7 miles NW. of San Antonio.	Loam, 0 to 18 inches	.6	1.3	1.0	3.9	7.7	37.6	47.4
10535	Subsoil of 10534	Gray loam, 18 to 36 inches.	.2	.4	.4	2.8	5.9	49.0	41.3
10533	Subsoil of 10532	White loam, 18 to 40 inches.	.2	.3	.2	2.0	7.7	47.1	42.2

The following samples contained more than one-half per cent of calcium carbonate ($CaCO_3$): No. 10532, 59.8 per cent; No. 10533, 73.4 per cent; No. 10534, 62.4 per cent; No. 10535, 63.1 per cent.

COLTON STONY CLAY.

The Colton stony clay consists of from 3 to 6 inches of loose, dark-colored clay, underlain by a rotten white limestone. It occurs typically developed in the city of San Antonio at Laurel Heights, and outside the city limits on Alamo Heights. It is also found in large, continuous areas in the high upland region in the northwestern part of the area. The shallow covering of soil on the surface is residual, having been derived from the underlying limestone. The elevation of the hills occupied by this type is due both to the resistance of the limestone to the agencies of weathering, and to the fact that the hills represent approximately a zone of faulting which occurred along the seacoast at the close of the Cretaceous period.

The Colton stony clay is characterized by its scrubby, stunted growth of liveoak and mesquite and cactus. Fragments of the underlying rock are often found strewn on the surface. Under present conditions this type of soil is of no agricultural value, except for the scanty pasturage it affords. It would make an excellent soil for goat ranches or vineyards.

The following table shows the texture of fine earth of this soil:

Mechanical analysis of Colton stony clay.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10536	9 miles W. of San Antonio.	Gravelly loam, 0 to 4 inches.	10.8	8.7	3.0	6.0	11.8	38.2	21.2

PORTSMOUTH SANDY LOAM.

The soil of the Portsmouth sandy loam is a bluish-gray to dark-colored sandy loam of fine to medium texture, having an average depth of about 18 inches. In dry weather it becomes so hard and compact that it can not be cultivated, and the roads become so hard that the hoofs of horses sound as if they were trotting on a pavement. In wet weather it absorbs moisture well. The subsoil is the same in texture as the soil. At about 3 or 4 feet below the surface it generally becomes yellow or red in color. The type is locally known as "black sand."

The Portsmouth sandy loam is confined to the sandy region in the southern part of the area and is usually closely associated with the Orangeburg clay. It is a residual soil, derived from the weathering of an underlying shaly sandstone belonging to the Tertiary. The surface is gently rolling and in some places nearly level, and the drainage good, except in times of unusual rainfall. There is greater danger of too little moisture than of too much. Comparatively little of the type is under cultivation, except in level areas and along stream courses, where the usual crops of the region are grown with fair success. Owing to the dense growth of mesquite which it supports, the clearing of this soil for cultivation is rather expensive.

Greater success would be attained on the Portsmouth sandy loam if it were cultivated in such a way as to preserve the soil moisture. This could be done by always keeping 2 or 3 inches of loose soil on the surface to destroy capillarity.

If properly handled the Portsmouth sandy loam produces fair yields of peaches, plums, and vegetables.

The table following shows the texture of typical samples of the soil and subsoil of this type.

Mechanical analyses of Portsmouth sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10555	Elmendorf	Dark compact sand, 0 to 8 inches.	0.4	3.0	7.6	40.2	13.7	14.8	20.7
10553	Kirk	Brown sandy loam, 0 to 6 inches.	.1	2.0	3.7	22.2	19.9	29.4	22.5
10554	Subsoil of 10553	Brown sandy loam, 6 to 36 inches.	.1	1.9	3.5	19.9	19.5	29.0	26.0
10556	Subsoil of 10555	Brown sand, 8 to 36 inches.	.6	2.8	5.4	26.8	10.4	19.8	33.9

The following samples contained more than one-half per cent of calcium carbonate ($CaCO_3$): No. 10553, 1.4 per cent; No. 10554, 2.3 per cent; No. 10555, 4.8 per cent; No. 10556, 13.2 per cent.

SAN ANTONIO CLAY LOAM.

The soil of the San Antonio clay loam is a brownish or chocolate-colored loam or clay loam, varying in depth from 8 to 12 inches, with an average of about 10 inches. As a rule, there is no definite line of demarcation, either in texture or color, between the soil and the subsoil. Below 12 inches and extending to about 24 inches the color grows gradually lighter, while the texture usually becomes a little heavier; thence to a depth of 36 inches the color changes to reddish, the texture becoming lighter, and the material usually grading into coarse limestone gravel or unconsolidated limestone conglomerate.

This soil is typically developed southwest of San Antonio, where there are large areas of it under irrigation. It extends along Leon Creek from the point where it enters the northwest corner of the area nearly to its junction with the Medina River. Another large area occurs east of San Antonio, along Salado Creek.

The San Antonio clay loam is derived from the even weathering of a pure, unconsolidated white chalk belonging to the Upper Cretaceous formation. This chalk is closely related to the limestone of the region, but differs from it in that it weathers more rapidly and uniformly and has no hard quartz particles in it. The San Antonio clay loam is therefore quite free from rock fragments of any kind, while the Austin clay and Houston gravelly clay soils derived from the limestone have rock fragments on the surface and disseminated through both soil and subsoil.

The areas occupied by the San Antonio clay loam are all quite level, but owing to the semiarid conditions of the region and the porosity of the soil their drainage is not difficult.

About 70 per cent of the type is under cultivation. That portion of it which lies in the artesian belt is irrigated, and is used extensively for trucking to supply local demands. It is a very productive soil, and owing to its level surface and the consequent ease with which it can be irrigated it is highly esteemed. Its average value in the vicinity of San Antonio is $100 an acre, and it brings an annual rent of $25 an acre. Northwest of San Antonio, along Leon and Culebra creeks, it is used almost entirely in the production of hay. In this locality the hills rise abruptly above the type, and it receives much of the drainage water from higher surrounding areas. Its valley position in this vicinity tends to make it one of the most desirable types in the area for the production of wild hay. The average yield is about 1 ton per acre.

East of San Antonio it is used for cotton, corn, and sorghum, the latter grown for forage. When the season is favorable the average yield of cotton is from one-half to three-fourths bale per acre, of corn about 35 bushels, and of sorghum from 2 to 3 tons.

Where irrigation is possible the type is the most desirable and valuable in the area. It makes an ideal truck soil and is excellent for such fruit as is suited to the climate. It is also adapted to cotton and corn, and alfalfa has been successfully grown. The texture of the soil is such that it absorbs moisture freely, and in times of drought the subsoil moisture rises readily. Although there is considerable sand in this soil, it can not be worked when wet, because of its tendency to pack and bake.

The following table shows the texture of the soil and subsoil of this type:

Mechanical analyses of San Antonio clay loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10542	5¼ miles SW. of San Antonio.	Black loam, 0 to 12 inches.	0.3	0.7	0.8	9.0	19.3	46.5	23.4
10544	10 miles W. of San Antonio.	Brown clay loam, 0 to 10 inches.	.7	2.4	1.6	7.4	12.5	46.6	28.8
10546	San Antonio	Brown clay loam, 0 to 10 inches.	.2	.6	.9	9.1	20.2	39.8	29.2
10543	Subsoil of 10542	Brown loam, 12 to 36 inches.	.4	.7	.7	8.6	17.0	45.2	27.1
10547	Subsoil of 10546	Light brown loam, 10 to 30 inches.	1.4	1.4	1.2	8.0	19.3	40.2	28.6
10545	Subsoil of 10544	Heavy loam, 10 to 36 inches.	1.4	1.8	1.2	5.8	11.2	49.0	30.1

The following samples contained more than one-half per cent of calcium carbonate ($CaCO_3$): No. 10542, 0.9 per cent; No. 10543, 9.8 per cent; No. 10544, 19.3 per cent; No. 10545, 26.4 per cent; No. 10546, 2.1 per cent; No. 10547, 12.9 per cent.

IRRIGATION.

The town of San Antonio, or San Fernando, as it was originally called, was founded with a view to utilizing the water of San Pedro Springs and the San Antonio River, and irrigation has played an important part in the development of the area.

Each of the five missions established along the river had its own irrigating ditches, and cultivated its own crops. After the arrival of the Canary Island colonists in 1730 it became evident that irrigation ditches were a public necessity, and water rights were granted to the various communities, and secured to subsequent settlers.

The irrigated areas were extended from time to time, to meet the demands of an increasing population, until in 1858 the city of San Antonio took charge of the ditches and appointed a ditch commissioner. The system was improved and other areas farther down the river were supplied with water.

After the advent of railways the delightful winter climate of the city attracted a large number of tourists, many of whom purchased permanent homes. A large part of the territory within the city, which had formerly been under irrigation, was gradually taken up for residences. The drilling of so many artesian wells for the city waterworks and other purposes so affected the underground supply as seriously to diminish the flow of the springs which supply the river, and as a result the supply for the ditches was insufficient. In view of these facts, and also in the interests of sanitation, the ditches, all of which headed above the city and flowed through it, sometimes serving the double purpose of ditch and sewer, were closed, except the San Pedro and Upper Labor ditches, which supply the gardens in the vicinity of the city.

Since the discovery of artesian water in the region south of San Antonio, irrigation has received a new impetus, and it is estimated that there are now 2,000 acres under irrigation in the area, and that there are in addition 4,000 acres which lie within the irrigable basin and can be irrigated.

Of the areas under irrigation, about 600 acres are irrigated by gravity, 400 acres by artesian water, and 1,000 acres by pumping. The city sewerage is carried in pipes and ditches to a point several miles south of the city and used for irrigation purposes. Some of the pumping plants referred to are situated in the southern part of the area along the Medina River.

It would thus seem that in spite of the diminution of the underground water supply, due to the drilling of so many artesian wells, the possibility of extending the irrigated area is by no means exhausted. The sewerage water from the city is being utilized, and water is now taken from the river below the city. It is quite probable, too, that a further artesian water supply can be found at a considerable distance south of the present source of supply, provided the wells are drilled deeper, as the dip of the water-bearing strata which supplies all the artesian wells in the vicinity of San Antonio is about 80 feet to the mile toward the southeast.

The crops grown under irrigation are cotton, corn, oats, grass, and garden vegetables. Orchard fruits, such as peaches, plums, and figs, also do well when irrigated. Garden vegetables are grown more extensively than any other crop, and are practically all consumed in the city of San Antonio. As larger areas are irrigated, and the supply outgrows the local demands, other markets will doubtless be found.

AGRICULTURAL METHODS.

The uncertainty of the seasons makes it unprofitable for the farmers to depend wholly upon crop production, and the high price of land makes it unprofitable for them to depend entirely upon stock raising. There are a few large ranches in the area which are used exclusively for grazing, but their owners purchased the land at an early date, when it was much cheaper than now. When lands cost more than $4 an acre it is considered that a profitable return on the investment can not be secured by raising stock exclusively. There is very little land in the area that can be purchased for less than $10 an acre. Nearly every farmer, however, raises some stock as an auxiliary to farming.

Aside from vegetables, cotton has become the principal money crop of the area. Plowing is usually done just before planting, and sulky disk plows are generally used. Before plowing, the cotton stalks are cut and burned or cut in short pieces and plowed under. In the black-clay lands level cultivation is practiced instead of planting the cotton upon ridges, as is done farther north, where the rainfall is more abundant. In the sandy region the cotton is planted in trenches so as to reach the subsoil moisture. When the cotton is cultivated the trenches are gradually filled up, so that by the time it is matured the ground is level or perhaps slightly elevated next to the rows.

In the sandy region near Elmendorf cotton has become the main source of revenue, and the credit system prevails, since the planter has money only once a year, when he sells his cotton in the fall. Some overestimate their ability to pay and can not meet their obligations to the local merchants, who are sometimes forced into bankruptcy as a consequence. The only remedies for such a condition are a more diversified system of farming and a ready market for the products grown. In the vicinity of Senior considerable interest is being taken in peaches, plums, and tomatoes, and a canning factory will likely be established at an early date.

One difficulty experienced by fruit growers is that the trees are short-lived, peach and plum trees having an average life of about eight years. This is possibly due in part to the so-called "sun-scald" injury affecting the southwest side of the tree, killing the bark. The lives of the trees may be prolonged by allowing them to branch close to the ground, thus providing shade for the trunk. The same result could be obtained by keeping the trees trimmed, and by driving a scantling, 3 or 4 inches wide, into the ground near enough to the tree to supply the necessary shade.

As yet very few cowpeas are grown in the area. The productiveness of such types as Portsmouth sandy loam and Orangeburg clay would be greatly increased by growing cowpeas, the roots of which would penetrate the hard, impervious soil and subsoil, and when the plants died the hollows in their roots would leave air spaces, and thus make the soil mellower and more retentive of moisture, besides adding to its productiveness by the increase of organic matter and nitrogen. Better cultivation would also aid in the retention of soil moisture. At present the fields are not well cultivated. There seems to exist a mistaken idea that in times of drought the ground will become drier if the fields are frequently cultivated. If shallow cultivation is practiced and kept up in dry periods, so as to retain a " dust blanket " on the ground, this destroys capillary connection from below, and the moisture is not evaporated from the surface as rapidly as where a crust is allowed to form. In such cultivation, however, care should be taken not to turn the soil over, but simply to loosen it.

The cotton yields of the area have been seriously diminished by the ravages of the boll weevil.

Heretofore the cotton planters have entirely neglected such matters as seed selection. They have sold to the oil mills their early seed, which is more vigorous for reproduction, and have retained for planting the late seed, which is of low vitality; or else they have bought unknown varieties from dealers, when by careful selection they might have developed a better strain of long staple. The farmers are beginning to realize this error, and in the near future some system of seed selection will be adopted.

LIVE-STOCK INTERESTS.

At the time of the first American settlement the Texas ranges were stocked with Spanish cattle from Mexico, and the State soon became noted as one of the great cattle-grazing regions of the world.

At an early date it was discovered by Texas stockmen that their cattle took on flesh much more rapidly in the cooler climate of the north. Besides, there was no home market for Texas stock. At that time cattle were so cheap that large numbers were often slaughtered for their hides and tallow. Hence the Texas ranchmen began to drive their cattle northward to the prairies of Kansas, Nebraska, and Dakota, there to be fattened and sent to market.

Some cattle were taken north before the civil war, but the great northward movement did not begin until 1866. After that time, during the spring and summer months, hundreds of thousands of cattle were driven up the trail to northern pastures. This manner of marketing continued until about 1887, at which time shipments by railroad began. At present Texas cattle are shipped quite generally to the corn-feeding States for fattening.

Formerly the cattle raised in this area were chiefly "natives" or "scrubs," very few belonging to good beef and dairy breeds. Most of the stock raised is for beef or feeding. Some of the farmers milk only enough cows to supply their own families with milk and butter, while others have small quantities to sell. No creamery butter is manufactured. Near the city of San Antonio are some large dairy herds of good breeding, which supply the city with milk.

Owing to the irregular and scanty rainfall of the area, there is often a shortage of feed, especially of a succulent nature, and farmers are often forced to feed cactus plants, after burning off the spines. One large dairyman near San Antonio has found silage feeding so profitable that he is building new silos before filling the old ones a second time. Silos can be constructed at a low cost, and their use affords a cheap and convenient means of storing feed. It is possible to fill them twice a year by using for the first filling an early variety of corn, such as the "Mexican June corn." Where irrigation is possible, alfalfa could be grown and fed with profit.

A large number of the farmers allow their stock to drink the stagnant water held in ravines by dams built across their lower ends.

San Antonio, which a few years ago was one of the large horse markets of the United States, has practically ceased to be a market at all. On two or three ranches Texas ponies are trained for the game of polo, and these bring fancy prices. The few mules that are raised are all taken by the local market. Not many hogs are raised, owing to the uncertainty of the corn crop.

In recent years steps have been taken toward the improvement of the native cattle, and now that northern cattle can be made so immune to the malignant Texas fever that less than 8 per cent of the cases prove fatal, the standard of Texas cattle should be materially and rapidly improved. No additional expense is involved in raising the better grades of beef cattle, aside from that of placing a high-grade animal at the head of each herd, and progressive stockmen have already learned the advantages of introducing the improved beef breeds.

AGRICULTURAL CONDITIONS.

The rainfall of the San Antonio area is too variable and usually too light for successful general farming, although many farmers of the area follow this system. It is probably most successful in the southern and southwestern parts of the area, on the sandy soils having clayey subsoils, and here the farmers are fairly prosperous. Elsewhere, outside the irrigated districts, the agricultural class, owing chiefly to the uncertainty of the seasons, is not in a very enviable condition, and it would be even worse if it were not for the popularity of San Antonio as a winter resort.

An army of health and pleasure seekers annually make this city their home, and much money is brought into the country in this way. Land values have risen in the last few years from $2 to $10 or $15 an acre for unirrigated tracts, and land under irrigation, which has always been much more valuable, is now held at from $150 to $200 an acre, with little for sale at any price.

About three-fourths of the farms of the area are worked by the owners. The uncertainty of the seasons tends to discourage the tenant class, whether they work on shares or pay a cash rent.

The greater number of farms range in size from 160 to 640 acres. The size varies greatly in the different types of soil, the largest farms being found on such types as the Colton stony clay or Houston gravelly clay, while the smaller farms are found on the types best adapted to diversified farming. Nearly all the old Mexican grants fronted on the rivers and often extended back several miles. In the subdivision of property among heirs each claimant wished to retain a river frontage. On the Medina and San Antonio rivers some of the grants have been divided and subdivided so many times that some of the holdings are now less than 100 feet wide and extend back from the river from 4 to 10 miles. The existence of these "shoe string" tracts, as they are called, is very unsatisfactory, and tends to retard the progress of the country. At the present time river-front advantages are regarded as desirable, but not absolutely necessary, in view of the fact that water can be obtained almost anywhere by drilling. Nearly every farm has from one to three windmills for pumping purposes.

The labor of the area is of a rather cosmopolitan character. There are Mexicans, Russians, Germans, Belgians, Italians, Americans, and negroes. The Belgians and Italians devote themselves almost exclusively to vegetable farming in the irrigated districts, and especially in the vicinity of San Antonio. Their work is very satisfactory, and they are much sought after. The Germans usually work by the month until they get a start, and then buy property of their own. They are thrifty, and make good citizens, being among the most successful farmers in the area. The Mexicans and negroes are employed largely by the day.

The crops grown are cotton, corn, fruit, vegetables, sorghum for fodder, native prairie hay, and winter oats.

The growing of vegetables is carried on principally in the vicinity of San Antonio, where the local markets are convenient and where irrigation is practicable. All of the soil types of the area, with the possible exception of the Colton stony clay, are naturally productive, needing only water. The San Antonio clay loam is very satisfactory for vegetables, and is used largely for that purpose near San Antonio. Ten miles northwest of San Antonio, along Leon and Culebra creeks, this type is used quite successfully for the production of native prairie grass, known as "sage grass." It contains enough sand to render it easily worked, and still has enough clay to make it retentive of moisture after irrigation. For trucking purposes it is recognized as more desirable than the Houston black clay, because the latter is too sticky and waxy, and upon drying has a tendency to bake and crack, thus "choking out" growing plants.

The Orangeburg fine sand is regarded as the best type in the area for all-around diversified farming without the aid of irrigation. The reason for this is that the loose sandy loam readily absorbs moisture, while the sandy clay subsoil is very retentive. Cotton and corn are the principal products grown upon this type. Watermelons and cantaloupes, as well as some smaller fruits, are grown, and the former are shipped in large quantities. The type is also well adapted to peaches and plums.

The Austin fine sandy loam is a very satisfactory type for all crops grown in the area when the season is not exceptionally dry. The subsoil being of a rather loose texture, the moisture is not easily maintained through very dry seasons. The type is used largely for cotton, corn, and sorghum for fodder.

The Austin clay is the most desirable type in the area for the production of prairie hay, the quality being excellent and the quantity averaging about three-fourths of a ton per acre. A ready market for the hay is found in San Antonio.

The Houston black clay loam, which resembles the Houston black clay, but is free from the disadvantages of the latter in that it does not bake and "choke out" the plants, is a desirable type for cotton and corn in favorable years. A large percentage of the type is under cultivation to the above crops, and some native prairie grass is also grown for the San Antonio market.

The Houston gravelly clay, Colton stony clay, and Houston black clay are types which are cultivated very little and are largely devoted to pasturage. It is upon such types that the largest farms are found, one of these containing about 7,000 acres.

The Orangeburg clay, in its typical phase, is regarded as too droughty for agriculture without irrigation, but by careful handling it produces fair yields of cotton in the most favorable seasons.

The Norfolk sand in the present area is nearly all worthless, because its subsoil does not retain moisture. In a few of the lower locations, where it has considerable moisture, it does very well for watermelons and cantaloupes.

The area is well supplied with railroads, connecting it with all parts of the United States and parts of Mexico. San Antonio is the railway center of the area. The Southern Pacific Railway (Galveston, Houston and San Antonio) passes through the area, giving it access to both the Atlantic and Pacific coasts. The International and Great Northern Railway connects with northern points and Mexico. Besides having these through lines, San Antonio is the terminus for the Missouri, Kansas and Texas Railway, the San Antonio and Gulf Railway, and the San Antonio and Aransas Pass Railway. The wagon roads of the area are excellent. The county is at present expending $500,000 for road construction. The flint and lime gravel of the region is being utilized for road building in the "black land" portion of the area, and in the sandy region the roads are being surfaced with clay.

The many railways give the area ready access to the markets of the country, but as yet very little fruit and vegetables are shipped out of the area, because the consumption at San Antonio has been greater than the supply.

SOIL SURVEY OF LAWRENCE COUNTY, TENNESSEE.

By CHARLES N. MOONEY and O. L. AYRS.

LOCATION AND BOUNDARIES OF THE AREA.

Lawrence County is situated in middle Tennessee, being one of the lower tier counties, and bordering on Alabama. The latitude of its southern boundary is that of the Tennessee-Alabama State line, which is approximately 35° north. It is bounded on the south by Lauderdale County, Ala., on the east by Giles County, on the north by Maury and Lewis counties, and on the west by Wayne County, Tenn. The area contains 395,456 acres, or, approximately, 618 square miles.

Lawrenceburg, with a population of about 2,000 and located near the center of the county, is the county seat. Other towns of some importance are Westpoint, Iron City, St. Joseph, Loretto, Wayne Station, and Summertown, all being situated along the Louisville and Nashville Railroad, which passes through the county in a general northeasterly direction.

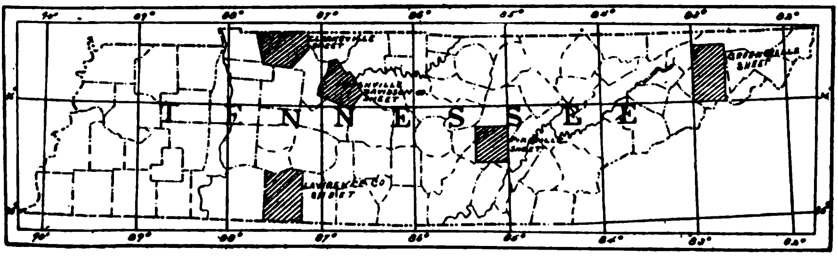

FIG. 19.—Sketch map showing location of the Lawrence County area, Tennessee.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

That part of Tennessee in which Lawrence County is situated was purchased from the Cherokee Indians by the United States Government in 1806. Some of this territory became known as the "Congressional reservation," and in the act of Congress establishing it the State of Tennessee was authorized to issue grants and perfect titles to certain lands within the territory.

It was not until 1815 that a white settlement took place within the region afterwards included in Lawrence County, and this is said to have been on Big Buffalo Creek, opposite to what is now the town of Henryville. These settlers were from North Carolina, as were many of those who subsequently came to this part of the State, and two years later another settlement was begun at Lawrenceburg. In 1817 Lawrence County was established by an act of the general assembly, but its actual organization was not completed until 1818, when the county court was organized. The county was cut off from "the territory south of Maury and west of Giles," and embraced a much larger area than now, reductions having been made from time to time.

The settlers located near springs, and the surrounding lands were always entered first. Military grants for services performed were given, and also occupants' grants. By 1850 small settlements were scattered over much of the county, extending along the larger stream courses where the lands were more productive. The streams abounded with fish, which formed an important part of the food of the people. These streams also furnished power to run their mills and other machinery, and, in the absence of roads, furnished outlets to other parts of the county.

Wild game was plentiful, and the pioneers subsisted largely by hunting. Small crops were produced, the principal product being corn, which has always been the leading crop of the county. Wheat was introduced at an early day, and tobacco was also grown for home consumption. Cotton was cultivated some time before the invention of the gin, being spun and woven into cloth by the women and by hand. As early as 1817 a cotton gin was built on one of the creeks and run by water power. In 1852 a cotton factory, run by the same power, was built and the building and operation of many others soon followed. Besides making threads and yarns, cloth also was woven. The raw product used in these factories, however, was not all grown in the immediate section, but was transported by wagon either from the Tennessee River or from the railroad in Giles County, the wagons hauling the raw material to the mills and returning with the finished products. These factories continued in operation until a few years ago, when, on account of inadequate transportation, it was found impracticable to compete in the markets with other manufacturing sections. Cotton is still grown to a limited extent in the southern part of the county.

In 1870 the German Catholic Homestead Association, organized in Cincinnati, Ohio, bought about 25,000 acres of land, mostly in the south central part of the county, which was disposed of in small farms, and at a nominal price, to those members of the association who desired to become settlers. This association brought in a good many families, and the thriving towns of Loretto and St. Joseph were built up by them. They settled upon the level uplands known as the "barrens," which, by the older settlers, were considered too poor to cultivate, but these people by their industry and thrift have made progress and are doing well. Small German settlements are now scattered over the county. Northern people are now coming in and buying these level uplands, preferring the land to their own in the North, being attracted also by the mild and desirable climate. The newcomers settle on the more level and poorer lands along the railroad, while the older settlers continue to occupy the creek bottoms. The broken and hilly lands in the remote parts of the county are still a wilderness.

Before the building of any railroad the transportation was entirely by wagon, and the markets and shipping points were at different places on the Tennessee River, the products being conveyed to other markets by boats. The first road constructed in this county was the Natchez "Trace," permission being given by treaty with the Indians in 1806. The road extended from Nashville to Natchez, Miss., and passed across the northwestern part of the county. Other roads were soon constructed through the county, the most notable one being the "Old Military road," put through by General Jackson between Nashville and New Orleans. It passes through the county near its center from north to south. These roads followed the ridges and were well made for the times, and have always been important highways, not only in the immediate section, but as outlets to other sections of the country.

About 1880 a branch line of the Louisville and Nashville Railroad was built from Columbia to Lawrenceburg, and in a short time extended to Florence, Ala. This railroad has been an important factor in opening up the valuable timber resources of the county and also in fostering agriculture near the towns along its route.

CLIMATE.

The appended table, compiled from records of the Weather Bureau stations at Iron City, Lynnville, and Waynesboro, gives the normal monthly and annual temperature and precipitation.

Iron City is situated in the southern part of the county, Waynesboro is in the county to the west, and Lynnville is in the county north of Lawrence. The data from these places are believed to represent fairly well the local climatic conditions in the intervening territory.

Lawrence County, being located on the Highland Rim, at an elevation of about 1,000 feet above sea level, has a very desirable climate, unmarked by great extremes of heat or cold. The winters are mild and practically without snow, even though farther south in adjoining States quite heavy snowfalls are sometimes reported. The ground is rarely frozen for more than an inch or two. The elevation of the uplands insures good air drainage, and late spring and early fall frosts are not of common occurrence.

The average annual precipitation for the three stations named is about 53 inches. This, as will be seen from the table, is fairly well distributed. However, the greatest rainfall is during the winter months, and during the last few seasons droughts have occurred in the early part of the growing season and also in the early fall.

Normal monthly and annual temperature and precipitation.

Month.	Iron City.		Lynnville.		Waynesboro.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	°F.	*Inches.*	*°F.*	*Inches.*	*°F.*	*Inches.*
January	40.1	5.67	38.8	5.27	38.5	4.76
February	39.6	4.36	40.7	5.54	40.8	4.66
March	51.1	8.40	48.9	6.40	49.4	6.26
April	58.8	5.78	58.5	4.99	58.7	3.87
May	68.5	2.54	68.5	4.05	67.0	3.06
June	75.5	5.80	76.0	4.04	75.4	4.12
July	79.4	2.82	78.9	5.50	78.2	4.50
August	78.2	4.98	77.5	4.27	76.7	4.22
September	71.8	3.40	70.5	3.64	70.0	3.16
October	61.6	2.38	60.2	2.87	58.8	1.91
November	50.0	4.25	48.8	3.63	48.2	3.60
December	40.6	6.28	41.3	4.61	40.9	4.14
Year	59.6	56.66	59.1	54.81	58.6	48.26

PHYSIOGRAPHY AND GEOLOGY.

The Highland Rim forms one of the physiographic divisions of the State, consisting of an upland region encompassing what is known as the Central Basin, a region lying at an elevation about 400 or 500 feet lower. The rim consists of a much dissected plateau whose general elevation is about 1,000 feet above sea level. Lawrence County is situated on its crest, the highest point being in the vicinity of Wayne, where the elevation is about 1,200 feet. To the north and south of this place the elevation decreases, and at the Alabama line is about 400 feet less. The streams have a rapid fall, Shoal Creek falling over 500 feet in its course through the county.

The topographic features of the county may be considered in three divisions—the broad uplands or plateau proper, the hills, and the terraces and bottoms along the larger streams. The uplands have a level to gently rolling topography and form the main stream divides, being more extensive in the north-central part of the county, where the streams head. These level uplands are known by the general names of " flat woods " or " barrens," the latter term having been applied because of a supposed infertility of the soils found in that section. As a rule the drainage is poor, and during the winter rains the lower lying areas are covered with water and become more or less swampy. About three-fourths of the surface of Lawrence County is hilly, consisting of narrow, irregularly shaped ridges with steep slopes to narrow valleys some 200 feet or more below. Near the heads of the streams the topography is only gently rolling, but farther down it becomes more rugged and extends back farther from the streams. The western and southern parts of the county are the more rugged, and considerable areas are so steep and stony that cultivation is either extremely difficult or impossible. Along the larger streams precipitous bluffs 100 feet or more in height occur. The bottoms and terraces along the larger streams are not extensive in this county, but outside of the area they become more extensive and important. Their occurrence is in the horseshoe bends and the longer inner curves of the streams, and they rarely occupy both sides of the streams, as usually on the outer curve the current swings into the bluffs. Often the first bottoms are entirely wanting. Such areas, however, generally consist of narrow first bottoms, from which rise gently rolling terraces or slopes, back of which the steeper slopes of the hills appear. They are, therefore, not the characteristic flat terraces found along most streams. Their formation, however, has been due to stream action and sedimentation, but probably at a time when the land was slowly rising or stationary for only short periods. The streams are still cutting their channels, and flood plains are not being developed. These terraces are spoken of collectively as "bottoms," though only a small proportion of them is subject to overflow.

The rock formations are all of sedimentary origin, and belong to the St. Louis group of limestones of Lower Carboniferous age. They consist of blue to gray, more or less siliceous limestones, with bands of chert, siliceous shales, and fine-grained sandstones. These strata are horizontal or nearly so, and outcrops are seen only along roadcuts and streams, although varying quantities of rock fragments occur on the surface and the proportion increases with depth until the fresh rock is encountered 10 feet or more beneath the surface.

The rock is more or less decomposed, the calcareous matter having been removed by solution, leaving behind the difficultly soluble siliceous matter. The chert consists of small angular fragments, while larger blocks of siliceous limestone are found, both occurring together and in varying quantities. The cherty material makes excellent road metal, and is used to some extent for that purpose. A narrow strip of phosphatic limestone extends through the county from north to south, passing near Springers Station; but it has no influence on the soils and has not proved of any value otherwise, being as yet undeveloped. In the western part of the county are several iron-ore deposits which are being mined. The ore occurs in layers on or near the surface. The iron-ore banks are said by geologists to mark the location of old bogs, in which mineral from the decomposing limestones was deposited. The ores promise to be of great commercial importance to the county, but as yet the industry has not been fully developed.

The drainage of Lawrence County is afforded by several streams, all having their source practically within the limits of the county and finally emptying into the Tennessee River. Sugar and Shoal creeks drain about three-fourths of the county, the former leaving the county at the southeast corner and the latter at the southwest corner. Between these creeks are Bluewater and Second creeks, which drain the central-southern part of the county. The northwestern part is drained by Buffalo Creek, and a portion of the northeast by Wet and Dry Weakley creeks, which flow over into Giles County. These are all rapid flowing streams fed by numerous springs along their courses. They are broad and shallow, flowing over rocky floors, and in their upper courses descend from one strata of rock to another, forming small falls, many of which are several feet in height.

SOILS.

The rock formations of Lawrence County do not give rise to a great variety of soils, and only four types have been recognized, the classification being made upon textural differences in the soil and subsoil. The name and actual and relative extent of each type are given in the following table:

Area of different soils.

Soil.	Acres.	Per cent.
Clarksville stony loam	263,296	66.6
Clarksville silt loam	113,664	28.8
Clarksville clay loam	10,880	2.8
Clarksville loam	7,616	1.8
Total	395,456	

CLARKSVILLE CLAY LOAM.

The soil of the Clarksville clay loam has an average depth of about 12 inches, and varies from a dark-brown to a reddish-brown loam or silty loam. The subsoil consists of material somewhat similar to the soil, but more compact and of a dark-red color, grading into a silty clay loam, which becomes stiffer in the lower depths. In depth the subsoil exceeds 36 inches, as shown by sections exposed in road cuts and wells. The underlying rock is nowhere exposed, but occasionally some siliceous rock fragments are found on the surface and in the soil and subsoil. Where this type comes in contact with the Clarksville silt loam, and in some other localities, a lighter phase occurs. In such places the color of the soil is somewhat lighter, but the red, heavy silt clay subsoil is found, as in typical areas.

The Clarksville clay loam is limited practically to the central part of the county, in the vicinity of Lawrenceburg and Wayne Station. There are three principal areas—one at Lawrenceburg, another to the south and west of Wayne Station, and a third, a strip about three-fourths of a mile wide, on the west side of Crowson Creek. A small area occurs near Henryville and two smaller ones in the southern part of the county.

The type is an upland soil occurring on the main stream divide. The surface varies from gently rolling to nearly level, and shallow basinlike depressions are sometimes found within the areas. The higher lying or gently rolling lands have fair surface drainage, but the more level areas are not well drained, and drainage is assisted by the use of open furrows. Underdrainage would prove very beneficial to this soil. The close texture of the subsoil makes the type retentive of moisture, and with proper methods of cultivation crops do not suffer from drought.

The Clarksville clay loam is a residual soil derived from the weathering of siliceous limestones. These have weathered deeply and uniformly, so that the soil formation is deep and the surface smooth and only gently rolling.

The Clarksville clay loam is recognized as the best soil in the county for general farming, and all of the type has been cleared and is under cultivation. Formerly, and particularly before the civil war, this land was devoted to cotton, and its continued cultivation to that crop greatly impoverished much of it. However, the once "worn-out" farms have been largely reclaimed by good methods of cultivation and are now quite productive.

The Clarksville clay loam is an easily worked soil, does not clod badly, and on the whole is friable and loose. The close-textured subsoil makes it retentive of fertilizer and moisture, so that with proper methods of cultivation the type responds readily and crops do not suffer from droughts in ordinary seasons. It is the best wheat soil in the county, producing on an average 15 bushels per acre, with maximum yields of 25 bushels or more for single fields not uncommon. Both winter and spring oats do well, and on some farms large crops of clover hay are obtained. Corn yields from 25 to 60 bushels to the acre. Cowpeas thrive, and it is a common practice to grow a crop of peas after the wheat is harvested, thus producing two crops in one season. The cowpeas prove very beneficial to the soil, and are employed very generally in maintaining and increasing its productiveness.

The Clarksville clay loam is claimed to be especially adapted to strawberries and cantaloupes. The strawberries grown are the Klondike and Gandy. The cantaloupes produced on this soil, as well as the strawberries, are said to be of superior quality.

The best improved farms are located in this type of soil, and range in value from $20 to $50 an acre; but little, if any, land of this type is on the market.

The mechanical analyses of typical samples of the fine earth of the soil and subsoil of the Clarksville clay loam are given in the following table:

Mechanical analyses of Clarksville clay loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12234	3 miles NW. of Lawrenceburg.	Brown silty loam, 0 to 12 inches.	0.9	3.7	2.9	6.6	3.3	64.1	18.1
12236	1 mile E. of Lawrenceburg.	Brown silty loam, 0 to 12 inches.	.1	1.1	.9	3.2	2.6	67.9	23.8
12235	Subsoil of 12234	Silty clay loam, 12 to 36 inches.	.5	2.2	1.4	4.2	2.0	57.7	31.4
12237	Subsoil of 12236	Silty clay, 12 to 36 inches.	.5	1.3	.6	2.0	1.6	58.4	35.3

CLARKSVILLE SILT LOAM.

The soil of the Clarksville silt loam, to an average depth of 10 inches, consists of a compact silt loam of gray, yellowish, or light-brown color, containing an appreciable amount of fine sand. In some locations the soil is much sandier and the grades of sand coarser. The latter is true of the higher-lying areas, and of areas bordering the Clarksville stony loam, while in the lower situations and basin-shaped depressions the maximum silt content is found. The soil has an ashy appearance and feel, and is sometimes spoken of as "white land," though the term "barrens" is a more common local name.

The subsoil is of similar texture to the soil, somewhat more compact and possibly a little heavier, becoming more silty and clayey in the lower depths. The color is yellow, sometimes reddish yellow, and in some places grades into a red, in which case the material is generally heavier and more clayey. From a foot to 2 or more feet below the surface the subsoil often becomes so compact that it is spoken of as "hardpan," although it can not be considered a true hardpan, as there is probably no cementing material, the compactness being due to the close arrangement of the particles, the clay filling in the interstices between the larger silt particles. On the tops and slopes of small ridges the subsoil sometimes rests upon the underlying rock at depths of 3 feet or less, but as a rule the depth of the soil formation is 10 feet or more. In the lower depths are found fragments and bowlders of siliceous rock more or less disintegrated and decomposed.

The Clarksville silt loam is one of the extensive soil types of the county, embracing large and irregularly shaped areas that follow the contour of the level upland or main stream divides. The most extensive development of this soil is north and west of Lawrenceburg, but it extends also southward between Shoal, Bluewater, and Sugar creeks.

The type occupies the greater part of the plateau and ridgy divides. The surface is nearly level to gently rolling, and at the heads of streams shallow basinlike depressions occur. Small ridges rising but a few feet above the general level are found. Because of the generally flat character of the surface the broad areas are known as "flat woods."

The Clarksville silt loam is a residual soil, derived from the breaking down of the siliceous limestone, the calcareous matter from which has been removed by solution and the siliceous matter left behind, gradually disintegrating and weathering to form the soil. Thin beds of very fine grained sandstone have also probably entered into the formation of this soil. As a rule no rock fragments are found in the surface 3 feet, although in some of the higher locations, as also where the type borders the Clarksville stony loam, there are enough fragments present to make the soil stony, and here the type may be considered a transitional phase between this soil and the Clarksville stony loam. At depths below 3 feet the quantity increases until the solid rock is encountered.

The usually level surface, the general compactness of the subsoil, and the presence of the more or less impervious "hardpan" stratum, do not favor either surface or subsurface drainage. Consequently on the more level areas water stands during wet seasons, and swampy conditions prevail temporarily. These portions are known as "slashes," and the characteristic timber growth is gum, willow oak, and post oak, the latter growing to large size. The Clarksville silt loam has always been considered too poor a soil to cultivate, and hence has remained in forest, and little or no attempt has been made to drain the wet areas. These lands no doubt would be generally benefited by tile underdrainage, and it is said that the moisture conditions are greatly improved by simply subsoiling as deep as possible. During a dry season the land becomes very dry and crops suffer even during short periods of dry weather.

With the exception of the "barrens" in the vicinity of Loretto and St. Joseph, only in recent years has a beginning been made to clear and put these lands under cultivation. The natural forest growth consists of chestnut, gum, and different varieties of oak, the white oak predominating. The scrub oak is usually found on the higher and poorer parts, while the willow, oak, and gum occupy the wetter portions. The value of the "barrens" in the past has been based entirely upon the timber that could be obtained. Where the heavier growth has been removed broomsedge and many species of wild legumes, the vetches predominating, furnish pasturage for live stock. These areas are all open and the live stock are allowed to range at will.

Where the land is cultivated the crops are wheat, corn, and cowpeas. This soil is considered better for wheat than the hilly land, principally on account of easier cultivation and harvesting, as improved machinery may be used. With ordinary cultivation and small applications of fertilizer, wheat yields about 8 or 10 bushels per acre, but yields as high as 20 bushels or more have been obtained with good methods. The soil is too susceptible to drought as a rule for corn to do well, the yields ranging from 10 to 20 bushels per acre. Another difficulty in growing corn is in getting it planted early enough, owing to the wet condition of the soil in the spring. This difficulty applies also to other spring-sown crops. This trouble could be removed by tile drainage, and something could be gained as well by preparing the land in the fall.

Cowpeas flourish on this soil, and are quite generally grown and cut for hay. The crop is known to be beneficial to the soil, although where hay is made too much of the crop is removed from the fields. It would be well if a crop like rye could be grown during the winter and turned under for green manure in the spring. This would greatly improve the tilth of the soil as well as furnish some plant food for the succeeding crop.

Garden truck and small fruits do well. Tomatoes grow to a good size and are of superior quality. Some of this land is especially adapted to sweet potatoes, in one notable instance a yield of 400 bushels to the acre having been secured. The average yield, however, is 200 bushels or less. The product finds a ready market, and a larger acreage devoted to the crop would prove profitable. Irish potatoes do not do so well, as the soil becomes too compact for them. This, however, might be obviated by the use of coarse littery stable manure and green manure, which have a tendency to keep the soil more friable and open structured. Turnips succeed exceptionally well, and for the limited quantity now produced good prices are obtained. Strawberries and cantaloupes do well on this soil and are promising industries. With these industries well developed the "barrens" will become in greater demand. These lands are being taken up now by northern settlers, some of whom are making improvements by drainage and introducing modern methods of cultivation for special crops. The soil can be easily improved, as has already been done in a few instances. The farms are large, usually exceeding 200 acres. This land brings from $2 to $10 an acre, the latter price being paid for that which is partly cleared and located near the railroad.

The mechanical analyses of typical samples of the Clarksville silt loam are given in the following table:

Mechanical analyses of Clarksville silt loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
12228	½ mile NW. of Crestview.	Silty loam, 0 to 12 inches.	0.2	1.8	1.5	4.3	2.5	67.5	22.1
12230	4 miles SW. of Appleton.	Heavy silty loam, 0 to 8 inches.	.6	1.5	.8	3.1	2.1	64.6	27.2
12229	Subsoil of 12228	Silty loam, 12 to 36 inches.	.7	2.1	1.7	4.1	1.6	64.9	24.9
12231	Subsoil of 12230	Silty clay loam, 8 to 36 inches.	1.6	1.4	.6	2.9	1.9	60.4	31.0

CLARKSVILLE STONY LOAM.

The soil of the Clarksville stony loam consists of a gray to brown loam, with usually a high silt content, but varying considerably in respect to this component, with differences in topographic position. On the higher elevations and slopes the soil is more sandy, while lower down it is more silty and loamy, becoming at times a silt loam, or at others a light loam. In places where erosion is not active organic matter is usually present in sufficient quantities to give the soil the appearance of a loam of dark color. The average depth of the soil is about 8 inches, and the depth varies little from this average. When dry the material has an ashy texture and feel.

The subsoil is silty clay loam, somewhat heavier in texture than the soil, the silt and clay content usually increasing in the lower depths. The color of the subsoil is generally yellow, but ranges through reddish yellow to red. The latter two, as a rule, are heavier than the yellow subsoil, the red often becoming a silty clay loam. The subsoil rarely exceeds 24 inches in depth and usually rests upon broken and more or less decomposed rocks. Upon the surface occurs from 10 to 60 per cent of angular rock fragments, varying in size from small gravel to blocks several inches in thickness. These consist of chert and parts of the siliceous limestones, fine-grained sandstones, and sandy shale, and occur also in the soil and subsoil, increasing in quantity with depth.

The Clarksville stony loam has a wider distribution than any of the other soil types of Lawrence County. It occurs in all parts of the county and in large areas, its greatest development being in the western and southern parts. It occupies all the hilly areas of the county and the slopes of the divides along the stream courses. The slopes, as a rule, are steep and difficult to cultivate. The rough topography of the type and its stony character insure good drainage.

The Clarksville stony loam is a residual soil, derived from the weathering of the underlying rocks, which consist of siliceous limestones with beds of chert, thin beds of fine-grained sandstone, and fine sandy shales. The calcareous matter in the rocks has been removed by solution, leaving the siliceous matter, which by disintegration forms the soil. The more resistant parts of the rocks and the chert are left as fragments upon the surface and in the soil and subsoil.

This type of soil is still largely in forest, the natural growth comprising various kinds of oak. In the higher situations, where the soil is shallower, the growth is mainly scrub oak, but lower down on the slopes, and particularly in the ravines, the timber is much heavier, consisting of chestnut, poplar, walnut, butternut, hickory, and different kinds of oak.

When the land is cleared it is devoted mainly to corn, which is the easiest crop to grow on the steep and stony hillsides, the yields varying from 15 to 35 bushels per acre. No crop rotation is followed and when the land becomes exhausted new land is taken up for cultivation. The new land produces good crops for about five seasons, after which time without the use of manure or fertilizer the yields decrease rapidly.

The Clarksville stony loam has always been recognized as a more desirable soil, even if more difficult to cultivate, than the "barrens" (Clarksville silt loam), as heretofore described. It is well adapted to corn, and good yields are generally obtained where the land has not been cultivated too long. The lower slopes are the more productive, the soil being more loamy, and the moisture conditions better. A difference is recognized in the exposure of the slopes, the northern being preferred. Clover does well on the northern exposures, but is grown by only a few farmers. Cowpeas have a thrifty growth and are quite generally grown. The greater part of this land is too steep and stony to be adapted to wheat, and practically none is produced except on the better locations, where fair yields are secured. Small fruits and garden vegetables do well. Some peaches of good quality are produced, and it is thought that apple orchards would do well, as the soil conditions seem to favor the growing of this particular fruit. A few new orchards have been set out.

The value of the Clarksville stony loam is determined largely by the character of its timber growth, the price ranging from $1 to $10 an acre.

The mechanical analyses of typical samples of the fine earth of both soil and subsoil are given in the following table:

Mechanical analyses of Clarksville stony loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
12240	9¼ miles W. of Lawrenceburg.	Loam, 0 to 8 inches	1.2	5.4	5.1	10.3	3.8	53.3	20.9
12238	1 mile NW. of Westpoint.	Silty loam to loam, 0 to 8 inches.	3.1	6.8	1.6	2.5	1.6	58.7	25.6
12241	Subsoil of 12240	Silty loam, 8 to 26 inches.	2.5	3.9	3.9	8.6	2.3	50.8	27.9
12239	Subsoil of 12238	Silty clay loam, 8 to 24 inches.	5.5	4.9	1.2	2.0	1.4	52.9	32.1

CLARKSVILLE LOAM.

The soil of the Clarksville loam, to an average depth of 12 inches, usually consists of a brown silty loam or loam. The subsoil is similar in texture to the soil and of a yellowish to light-brown color, but is more compact than the soil and increases in silt and clay content in the lower depths, becoming in some places a silty clay loam. At a depth of about 2 feet or more a stratum of broken rock fragments is usually found. These fragments are usually cherty and small and occur on the surface and in the soil and subsoil in sufficient quantity to give the type a gravelly character, the amount of rock fragments often equaling that contained in the Clarksville stony loam, in which case the boundary between the two types is arbitrarily drawn. This soil could be considered as a phase of the Clarksville stony loam, as it is largely derived from the latter; but because of its position and higher agricultural value it has been classified as a separate type. It is somewhat variable and often contains enough fine sand to give it the character of a fine sandy loam.

The Clarksville loam occupies areas locally called "bottoms," which usually consist of a narrow first bottom and a gently rolling terrace, extending back some distance to the steeper slopes of the hills. Its highest part does not exceed 50 feet above the stream beds. Sometimes the first bottoms are wanting, especially along the smaller streams, in which case the terrace starts from the streams. Farther down the streams and out of the county the bottoms are more extensive. The best development is in the large bends of the streams and on the inner side of the long curves. Rarely do the terraces occur on both sides of the stream at the same point.

The Clarksville loam is of limited extent in this county, the largest areas occurring along Shoal Creek and its main tributaries. There are also considerable areas along Sugar and Buffalo creeks, while along all the streams narrow strips occur, many of them too small to be shown on a map of the scale used.

This type is sedimentary in origin, consisting of the wash from the adjacent higher slopes, together with material deposited from the streams in times past. All the material has been reworked by stream action, and assortment has taken place to some extent, as shown by strata of rock fragments found in the finer material.

The Clarksville loam has always been considered very desirable land for general farming. The bottoms were the first lands to be cleared, and many of the fields have been under cultivation ever since the settlement of the county. Good moisture conditions usually prevail, and crops rarely suffer during droughts. Corn has always been the principal crop, and the yields range from 20 to 60 bushels or more per acre, the largest yields being obtained on the lower and better portions. Wheat, oats, and rye also do well, the yield ranging from 10 to 25 bushels per acre. Clover thrives and some very large crops of hay are secured, and with the prices obtained this is a very profitable crop, and one which should be grown more generally. Cowpeas produce large crops. Grasses will also grow well, furnishing good pasturage as well as hay. The cotton produced in Lawrence County is grown mostly upon this soil, yielding as much as one-half bale to the acre.

Crop rotation is not generally practiced, but on a few of the better farms a rotation of corn, wheat, and clover or cowpeas is followed. Fertilizer is not generally used on this soil. Subsoiling has been practiced to some extent and has proved beneficial. Some of these bottom lands are valued as high as $75 an acre. Usually, however, the bottoms are included in farms, of which the uplands form a part, and the average price of both is much lower than is the case when the bottoms are taken separately.

The mechanical analyses of samples of the fine earth of the soil and subsoil of the Clarksville loam are given in the table following.

Mechanical analyses of Clarksville loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12242	4 miles W. of Henryville.	Brown silty loam, 0 to 10 inches.	1.2	3.2	2.9	4.0	1.2	64.2	23.3
12244	4 miles E. of Pinkney	Brown silty clay loam, 0 to 12 inches.	1.0	2.7	1.2	2.4	2.5	59.8	30.3
12243	Subsoil of 12242	Brown silty loam, 12 to 24 inches.	1.1	2.7	2.2	3.6	1.4	62.6	26.2
12245	Subsoil of 12244	Brown silty clay loam, 12 to 30 inches.	1.0	1.4	.7	1.9	2.2	59.9	32.6

AGRICULTURAL CONDITIONS.

Lawrence County is still largely forested, it being estimated that not more than one-fourth of the land of the county is cleared and under cultivation. Therefore interest is centered largely in the forest products. The income from the different lumbering industries reaches several hundred thousand dollars annually, and the work of getting out the timber and operating the mills gives employment to a large proportion of the people. In fact, nearly all the inhabitants are more or less engaged in this work. It is only since the building of the railroad that it has been possible to exploit the forest resources of the county, and prior to 1880 both the land and timber had little money value. The forest growth is fairly heavy, and consists of different varieties of oak, the white and post oak predominating, and chestnut, with some poplar, walnut, and hickory.

The cleared lands, which, as heretofore stated, occupy about one-fourth of the area of the county, have until recently been limited to the bottoms and terraces along the creeks and the slopes of the adjacent hills, which represent the more productive soils and better locations in the county. Farming operations, therefore, have not yet become extensive in Lawrence County. The average size of the farms, according to the Twelfth Census, is 127.2 acres. The holdings of timbered lands are much larger, there being some tracts of several thousands of acres. The size of the farms is steadily decreasing with the influx of new settlers, who buy small bodies of land. Of the total acreage in farms only about one-third is improved. The dwellings are small and plainly constructed plank houses, although there are a few modern houses only recently built.

The outbuildings are small and few, and, in general, no provision is made for housing live stock, with the exception of horses. The common worm rail fence incloses the cultivated fields. On some of the wooded lands where the timber growth is not very thick, particularly on the Clarksville silt loam, or "barrens," there is a growth of broomsedge which is said to afford a fair pasturage for stock, especially in the early spring.

According to the last census 64 per cent of the farms are operated by the owners. Where farms are rented it is on a share basis, a certain portion of the crops produced going to the owners. There is very little labor hired on the farms. As a rule the labor is efficient and the wages paid are reasonable.

Until the past year agriculture has been mainly confined to the production of the staple crops—corn, wheat, and some cotton—together with certain vegetable crops needed for home consumption. As there is no diversity in the soils there has been a consequent lack of diversity in crops. The lands cultivated being more or less steep or stony, those crops have been grown which could be cultivated with the least difficulty.

Corn succeeds better than any of the other farm crops. It can be grown on the steep stony hillsides with an assurance of a crop of some kind. The average yield for the county is about 20 bushels per acre, although as high as 60 bushels per acre is not uncommon on the Clarksville clay loam. Corn makes a very rank growth, producing a large quantity of fodder. The general method of harvesting is to strip the leaves and later snap off the ears, storing with the husks on and husking the corn as needed. Some of the settlers from the north follow the northern method of cutting and shocking the fodder. On some of the best farms corn harvesters, huskers, and shredders are now in use. The acreage in corn is nearly double that of all the other crops combined.

Wheat is the crop of next importance to corn. The yield as a rule is not large, although on some of the bottoms and level uplands yields ranging from 20 to 30 bushels per acre are reported. The rugged stony lands are not suitable for wheat, because of the difficulty in planting and harvesting.

The acreage in oats is increasing and cowpeas are grown on nearly every farm. The crop is cut for hay, which forms practically the only kind of hay produced in the county. Clover does well on all the soils except the "barrens." On the Clarksville stony loam it does best on the hill slopes with northern exposures. This crop should be more generally grown and given a place in a crop rotation.

Some cotton is grown in the southern part of the county, but the growing season is hardly long enough and the soils are considered too thin for its profitable production. There is a tendency, however, to a revival of cotton growing, because of the expectation of higher prices owing to decreased production of cotton on account of the ravages of the boll weevil elsewhere, the insect not having yet appeared in this section of the State. Some effort is being put forth to introduce tobacco growing. A cigar filler leaf has been produced, but its quality is in question and it is not thought likely that tobacco of this type would prove a profitable crop on these soils.

As stated elsewhere in this report, the Irish potato does not succeed in Lawrence County soils, but the sweet potatoes produced are of excellent quality, and their production should be increased. Good prices are obtained for the small shipments made, a few carloads being sent annually from Summertown. A yield of more than 400 bushels per acre has been reported, and with proper methods of cultivation the average yield should be not less than 200 bushels.

Tomatoes of a superior quality are profitably grown. A canning factory has been established, and it is probable this industry may be developed. The vegetables produced on the Clarksville silt loam find good market at the iron mines within the county and at the phosphate mines in Maury County.

Except by a few of the best farmers no crop rotation is followed. The rotation used by them consists of corn, wheat, and cowpeas sown immediately after the wheat is harvested. Sometimes cowpeas are planted in the corn. Systematic crop rotation should be more generally practiced, and either cowpeas or clover should be one of the crops included. Cowpeas will be found especially valuable, as they do well on all the soils. The rougher lands are cultivated solely to corn, and in a few seasons when the yields decrease greatly the fields are abandoned and new land is cleared for cultivation. Improved farm implements have been introduced within recent years and are now quite generally used.

With the removal of the forest and the settlement of the level uplands, locally known as the "barrens," the development of a better agriculture seems to be assured. Until recently these lands were considered of little value except for the timber growth, and while it is true the soil is not adapted to the staple crops, it has been ascertained that certain special crops will do exceptionally well, and the indications are that the "barrens" in a few years may become the most desirable and profitable land in the county, especially where located near the railroad stations.

It is claimed that this upland soil is peculiarly adapted to the growing of strawberries and cantaloupes, and to these crops an increased acreage will be devoted the coming season. The strawberry vines bear heavily and the berry is of superior quality, the varieties best suited to the soil being the Gandy and the Klondike, which ripen after the strawberry crop produced farther south has been disposed of and before the northern crop is ready to be marketed, thus insuring good prices.

The Rockyford cantaloupes produced on this soil are said to be as good, if not superior, to any grown in the United States outside of the irrigated districts. The vines bear exceptionally well, the fruit is well netted, and the meat is thick and of superior flavor. The strawberries and cantaloupes will be shipped in refrigerator cars in carload lots to northern markets, reasonable transportation rates being assured by the railroad officials. Several hundred acres are to be planted to both crops, and the prospect at this time seems to be bright for the development of these industries. Associations of growers have been formed in the county.

At present the greater part of the population of Lawrence County is composed of people from the more northern States, and settlers from that region, both farmers and skilled mechanics, are still investing in the level uplands and near the railroads. They are introducing improved methods and doing much for the betterment of the county. The elevation and moderate climate, together with the abundance of good spring water, makes it a healthful and desirable part of the State, and these considerations have aided in no small degree in influencing settlement.

The rural free delivery of mail is being extended in the county, and local telephone lines are used by many of the farmers.

The Louisville and Nashville Railroad, which passes through the county, has been an important factor in stimulating agricultural interests, as well as adding to the value of the timber resources, affording an access to outside markets for both the agricultural and forest products of the county.

SOIL SURVEY OF THE GREENEVILLE AREA, TENNESSEE-NORTH CAROLINA.

By CHARLES N. MOONEY and O. L. AYRS.

LOCATION AND BOUNDARIES OF THE AREA.

The Greeneville area is located in East Tennessee, with the southeastern portion extending over the Tennessee-North Carolina line and including a portion of Madison County, N. C. The area surveyed comprises the western two-thirds of the Greeneville sheet of the United States Geological Survey.

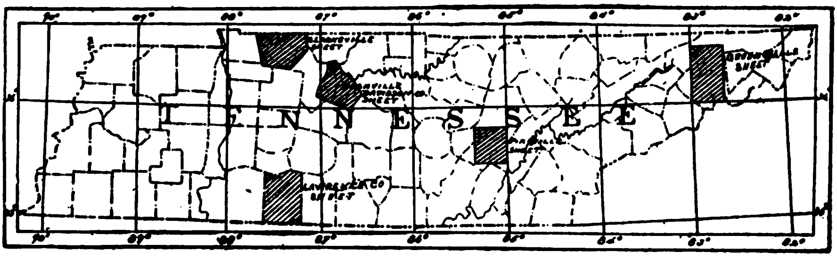

FIG. 20.—Sketch map showing location of the Greeneville area, Tennessee.

The area is bounded by the meridians of 82° 40′ and 83° west longitude, and by the parallels of 36° and 36° 30′ north latitude. These boundaries form a rectangular-shaped area approximately 34 miles long from north to south by 19 miles wide from east to west, comprising a total of 424,960 acres, or 664 square miles.

The counties represented in the survey are Greene, Hawkins, Sullivan, and Cocke, in Tennessee, and Madison in North Carolina, two-thirds of the area lying within Greene County and most of the remaining third in Hawkins County.

The area is in the oldest settled part of Tennessee, and since the establishment of the counties named, first as a part of North Carolina, then as the "State of Franklin," and finally in Tennessee, they have been devoted entirely to agriculture, and have been known more or less prominently as agricultural communities.

Greeneville, the largest town in the area, with a population of something over 3,000, is the county seat of Greene County, and was the capital of the temporary State of Franklin. It is now a thriving business town. Rogersville, with a population of about 1,000, is the county seat of Hawkins County and lies just outside the area. In the early history of Tennessee it was the State capital.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Before its settlement by white people this part of Tennessee was the hunting ground of numerous Indian tribes living to the south and north. The "barrens," or treeless portions, afforded a rank growth of grasses, the feeding grounds of herds of buffalo, elk, and deer, and the canebrakes along the stream courses were a refuge for bears.

To this section about 1750 or soon thereafter came adventurous hunters from Virginia and North Carolina, seeking hunting grounds where game was plentiful and furs could be obtained. It was with these hunters that agriculture had its beginning, as when their trips extended over a season or more they grew small crops of corn.

Within a few years after the advent of the hunters settlers from Virginia and North and South Carolina began to move to the new country, where land could be bought for little or nothing from the Indians. In 1772 some Virginians settled in Carters Valley, near what is now Rogersville, in Hawkins County. Settlement was begun in Greene County in 1778, along the Nolichucky River and Lick Creek. Those who had obtained larger tracts or grants of land offered good inducements to settlers, and settlement became quite rapid, being facilitated by the building of a road across the mountains. Virginia supplied numbers of settlers, while from Pennsylvania came Quakers, Scotch-Irish, and Pennsylvania Dutch. By 1795 the population of Tennessee had increased to more than 60,000. Soon after its settlement Tennessee had been annexed to North Carolina, forming what was called Washington County. In 1783 Greene County was formed, being the third in Tennessee.

The settlers were at first engaged in the fur trade. Wild game was plentiful and furnished them with food, as well as winter clothing and furs for trade. They grew some garden vegetables. Corn was grown from the first and became the principal crop, wheat and other small grains being introduced later. The growing of corn, however, continued to hold the leading place, and by the census of 1840 Tennessee ranked first among the corn-producing States.

Hemp and flax were grown generally, but only for home consumption. Prior to the civil war considerable hemp and flax were produced in Greene and Hawkins counties, but after the war the production decreased and was finally abandoned. Cotton was grown at a later date, but never on a commercial scale. These products were all prepared at home and, with the wool obtained from the sheep raised, were woven into homespun clothing by the women.

The raising of live stock, particularly hogs, as they were easily marketed, later became an important industry. The markets in those days were Baltimore, Md., and Augusta, Ga., and roads were built to these places. The latter place being nearer and having the better route, most of the live stock and other products were taken that way, and thence by water to Baltimore or some other northern market. Later transportation was facilitated by the use of flatboats on the rivers at times of high water. These were the only means of communication until 1858, when the East Tennessee Railroad was completed and put into operation. This road became a great factor in the development of the region.

Besides the crops already mentioned, the earlier settlers grew tobacco, but only in quantities sufficient for home use. Tobacco also became a medium of exchange. It was not until about 1882 that this crop was grown on a commercial scale. At that time there was need of a money crop, and as the land would produce tobacco and the prices were such as to make its culture profitable, it was taken up generally by the planters. The tobacco grown was mostly a bright smoking tobacco, the best grading as a bright wrapper. Some Burley tobacco was also produced. The tobacco was grown on all the sandy valley lands and on the white sandy lands south of the Nolichucky River, which form the lower slopes of the Blue Ridge Mountains. Tobacco growing is now entirely confined to the latter soils. The land was cultivated continuously to tobacco and soon decreased in productiveness, while the price has fallen to a point where the crop ceases to be profitable, so that the industry has been abandoned on the valley soils.

The tobacco market for the first two or three years was at Bristol, but since 1885 it has been at Greeneville, which is the only bright tobacco market in Tennessee.

CLIMATE.

The following tables, compiled from the Weather Bureau records for Greeneville, Rogersville, and Newport, show the normal monthly and annual temperature and precipitation for the area, and the occurrence of the last killing frosts in spring and the first in fall. These stations are representative of the greater part of the area. Greeneville lies near its center, while Rogersville and Newport are just outside. Rogersville, in Hawkins County, may be said to represent the ridge district, while the situation of Newport corresponds with that of Greeneville.

From the appended figures it will be seen that there is very little difference in temperature and precipitation over the area. The winters are mild, but there are cold periods when the temperature approaches zero, though these are of short duration. At Greeneville the snowfall amounts to about 15 inches annually. The area lying at considerable elevation and near the mountains the summers are temperate and, although during the day the temperature may be high, the nights are always cool. Unseasonable frosts frequently occur and make fruit growing uncertain.

The rainfall is fairly well distributed, the last four months of the year being the dryest. Often the rainfalls are heavy, and early summer droughts are apparently becoming more common.

No data are available for the mountain section of the area, which covers only a small territory, and one of no agricultural value. Its climatic conditions are quite different from those of the valley, owing to its much greater altitude. The climate is much colder and the growing season shorter.

Normal monthly and annual temperature and precipitation.

Month.	Greeneville.		Rogersville.		Newport.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	° *F.*	*Inches.*	° *F.*	*Inches.*	° *F.*	*Inches.*
January	36.5	3.68	35.7	3.87	38.3	3.73
February	39.3	4.12	38.5	4.63	39.7	4.07
March	46.4	5.11	46.0	5.28	47.6	5.40
April	56.3	3.40	56.0	3.51	56.9	3.38
May	64.6	4.12	64.5	3.94	65.9	4.20
June	72.1	4.90	71.9	3.91	74.3	4.26
July	74.8	4.68	74.5	4.55	76.9	4.29
August	73.3	4.62	73.5	4.16	75.5	4.36
September	68.7	2.36	68.1	2.47	69.4	2.44
October	56.8	2.51	56.1	2.51	57.6	1.79
November	46.6	2.42	46.4	2.90	46.4	2.71
December	39.2	2.96	38.0	3.47	38.6	3.15
Year	56.2	44.88	55.7	45.20	57.3	43.78

Dates of first and last killing frosts.

Year.	Greeneville.		Rogersville.		Newport.	
	Last in spring.	First in fall.	Last in spring.	First in fall.	Last in spring.	First in fall.
1896	Apr. 7	Oct. 19	Apr. 8	Oct. 19	Apr. 5	Oct. 19
1897	Apr. 18	Oct. 30	Apr. 18	Oct. 30	Apr. 18	Nov. 4
1898	Apr. 8	Oct. 15	Apr. 6	Oct. 15	Apr. 8	Oct. 19
1899	Apr. 17	Sept. 30	Apr. 17	Sept. 30	Apr. 17	Nov. 4
1900	Apr. 13	Nov. 5	May 4	Nov. 5	Apr. 6	Nov. 8
1901	Apr. 24	Oct. 15	Apr. 16	Nov. 5	Apr. 21	Nov. 6
1902	Apr. 5	Oct. 15	Apr. 12	Oct. 29	Apr. 8	Nov. 29
1903	Apr. 24	Oct. 25	Apr. 24	Oct. 25	Apr. 5	Oct. 25
Average	Apr. 15	Oct. 19	Apr. 17	Oct. 23	Apr. 11	Nov. 3

PHYSIOGRAPHY AND GEOLOGY.

The Greeneville area covers parts of the Great Valley of East Tennessee and the Appalachian Mountains. These two sections are included in what is known as the Appalachian physiographic province, and represent two of its three main divisions, namely, the Great Appalachian Valley and the Appalachian Mountains. These divisions extend the entire length of the province, or from southern New York to central Alabama. Their trend is northeast to southwest. In the different States through which these divisions pass local names have been applied. The valley portion of the Greeneville area belongs to that portion of the Great Appalachian Valley known as the Great Valley of East Tennessee, while the mountains belonging to the Appalachian system are known along this portion of the Tennessee and North Carolina line as the Bald Mountains.

The rock formations of the entire area are of sedimentary origin—that is, they were laid down in water. These consist of sandstone, shale, and limestone, all presenting great variety in composition and appearance. The materials composing these rocks were originally gravel, sand, and mud derived from the waste of older rocks farther east, together with the remains of plants and animals.

The age of the rock formations ranges from early Cambrian to Carboniferous, but the Devonian and Carboniferous formations are small and unimportant. The Silurian furnishes the greater number and the most important.

The valley portion of the Greeneville area occupies about seven-eighths of its total extent, the greater part being included in Greene and Hawkins counties, with only small portions of Sullivan and Cocke counties.

The rock formations of the valley are sedimentary and more or less calcareous, consisting of limestone, shale, and sandstone, and comprising a great variety of each. Originally the strata must have been laid down horizontally, but by the movements that took place later they have been folded and broken, and now intersect the surface at various angles and in belts. As these rocks vary in composition and hardness, the rate of weathering has been different. The harder and more resistant rocks, like the sandstones and cherty limestones, form the ridges, while the softer and more soluble rocks, like the purer limestones and shales, form the intermediate valley floors. Thus from each kind of rock certain characteristic surface features are obtained, which may be divided into districts or belts corresponding to the underlying rock formations. These are the limestone and shale belts, which together form the valley proper and the ridge district. Each of these belts or districts forms the drainage basin of one of the principal streams of the area.

The limestone belt forms the drainage basin of the Nolichucky River. It lies on the eastern side of the valley, and its surface features consist of a series of high, rolling ridges, with narrow intervening valleys. The slopes are, as a rule, smooth and gentle, and adapted to cultivation. The ridges run with the valley and parallel to each other. At intervals they break down, and the larger streams cut through the gaps, while the smaller streams follow the valleys. The elevation of this section averages about 1,400 feet above sea level, ranging from 1,100 feet, where the Nolichucky River leaves the area, to nearly 1,800 feet on the higher cherty ridges bordering the western portion of the belt. Numerous sinkholes are also a prominent feature in the topography, and afford partial drainage.

The underlying rocks consist of a series of blue, gray, and whitish limestones and dolomites, the magnesian limestone or dolomite, known as the Knox dolomite, predominating, while in the beds are nodules and masses of black chert. Besides the chert the Knox dolomite contains only 5 to 15 per cent of earthy matter, and on account of the great solubility of its material decay is rapid and the resulting soil formation is deep, leaving a stiff red clay, over which lies the fine sandy to silty or loamy soils, with the cherty matter concentrated on and near the surface. The amount of chert varies from practically nothing to an amount so great as to make up the larger part of the surface and preclude cultivation. When weathered the cherts are white and broken into sharp, angular fragments.

Economically, the limestone formation furnishes building material, lime, and road metal. A narrow belt of the limestone in Hawkins County has been changed to a marble, which has been quarried for ornamental and building material.

The shale or "knob belt," as it is called, occurs next to the limestone belt on the west. It extends across the area in a northeast and southwest direction, and through its center Lick Creek follows a winding course. The characteristic topography of the shale formation consists of rounded knobs and irregularly shaped ridges without any arrangement, rising from 200 to 300 feet above the small, narrow valleys between. On the northern side of the belt, and as it approaches the east, the hills are not so high and the topography is more rolling. A narrow knob belt also occurs along the Holston River.

The Lick Creek Valley is wide, and extensive flood plains have been built up along it and its principal tributaries composed of the wash from the adjacent shale slopes. The sediment forms a heavier soil than that in the limestone formation, it being strong and fertile and agriculturally one of the most important soils in Greene County.

The elevation of the knob belt varies from 1,100 feet, where

Lick Creek leaves the area, to 1,500 feet above sea level on the highest knobs.

The underlying rock formations consist of shales, varying from argillaceous to sandy, thick to thin bedded, and more or less calcareous. The shales, being soft rocks, weather rapidly, but erosion is active and the resulting soil formation is shallow. The complete weathering of the shale produces a stiff, plastic, yellow clay loam or clay, through which are scattered varying amounts of more or less decomposed shale fragments.

The ridge district occupies the northwestern part of the area. It is characterized by a number of long, narrow, parallel ridges or mountains, separated by narrow valleys.

The rock formations of this section are sandstone, shale, and limestone, all occurring in narrow, alternating belts. The ridges are composed of red and white sandstone, the white forming the top layer. This stone is very resistant to weathering, which condition results in narrow, sharp ridges, with the upper slopes, especially on the southeastern side, forming cliffs; while below these there is a short talus slope, the débris covering the shales. Usually the slopes are very stony, though some parts of the ridges, where the beds are not tilted at such an angle, weather more uniformly, forming rounded tops or knobs, with gentle slopes, and to these has been applied the term "comby ridges." The elevation of these ridges is about 2,000 feet, with some higher points culminating in a sharp peak—Chimney Top—at an elevation of 3,076 feet above sea level, and the highest point in the valley. South of the Holston River shales and shaly limestones form the valley floors, their surfaces being gently rolling to moderately hilly. North of the Holston the valleys were formed from limestone with narrow belts of shale. These valleys, too, are gently rolling. The narrow strip of shales may be traced by the series of knobs characteristic of the shale formations.

The elevation of these valleys averages about 800 feet lower than the ridges, or about 1,200 to 1,300 feet above sea level.

The drainage of this section is into the Holston River. The largest tributaries are Beech Creek on the south and Big Creek on the north. The ridges are broken down in a few places, and these creeks flow through the gaps thus formed. Both creeks are strong and rapidly flowing streams.

The Bald Mountains extend across the southeastern portion of the area, not occupying more than one-eighth of the total area surveyed. This section is characterized by a main ridge trending from northeast to southwest, with an elevation of about 4,400 feet, culminating in Camp Creek Bald, with an elevation of 4,760 feet above sea level, and the highest point within the area. From the main ridge numerous sharp spurs extend out on both sides at right angles. These are only a few hundred feet lower than the main ridge, and are rough, stony, and practically inaccessible. The main ridge has in part a broad, rolling top, but the slopes are steep, being either sheer precipices, hundreds of feet high, or steep, stony, talus slopes. Lower down, on the western side, at about the 2,000-foot contour, the slope becomes gentle and extends out from 2 to 4 miles toward the Nolichucky River. Over much of the gentle talus slope are scattered rounded, water-worn bowlders of sandstone, in many cases sufficient in number to prevent cultivation, while in other places they are entirely lacking. the slopes having evidently been old sand bars.

The rock formations of the Bald Mountain section consist of sandstones varying from fine to coarse and moderately coarse conglomerates, and quartzites. Shaly sandstones and sandy shales are also present. Disintegration has been the force breaking down these formations, and as the sandstone is quite resistant, weathering has been slow, leaving steep-sided mountains. The resulting soil from these rocks is a yellowish or sometimes reddish sand, with but little organic matter and low productiveness.

Small, rapid mountain streams drain this section. Hickey Fork and Paint Creek are the principal streams on the east, while numerous creeks drain the western slope and empty into the Nolichucky River.

SOILS.

The rock formations of the Greeneville area afford a great variety of soils. In all, ten types have been classified and shown on the accompanying map. The basis of classification has been mainly one of textural difference, as shown in the field, but has taken into account also the derivation and agricultural value. The soils, with the exception of two types, are of residual origin; that is, derived from the underlying rock in place. The soil types have been correlated when possible with similar soils of East Tennessee and Alabama, which had been established and described previously to the survey. The name and actual and relative extent of each soil type are given in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Dekalb stony loam	99,072	23.3	Meadow	17,216	4.0
Fort Payne loam	83,520	19.7	Dekalb silt loam	10,560	2.5
Dekalb shale loam	64,896	15.3	Fort Payne clay loam	9,536	2.2
Fort Payne stony loam	64,386	15.1	Cumberland loam	7,040	1.7
Fort Payne clay	47,168	11.1	Total	424,962	
Decatur clay	21,568	5.1			

FORT PAYNE LOAM.

The soil of the Fort Payne loam consists of a fine to medium slightly sandy loam, varying from a gray to yellowish or brown color. In general the type is a medium, slightly sandy loam, but in some situations the texture becomes finer, being almost a silty loam. The depth of the soil varies from 8 to 18 inches, but the average depth for the whole area is probably about 12 inches.

The subsoil consists of a yellowish-red clay loam, grading generally in a few inches into stiff clay, which at lower depths becomes a deep-red color. The clay loam, however, often extends to greater depths or in many cases is not present, the soil resting upon the stiff red clay. Usually some small cherty fragments are present in the soil, but not to exceed 10 per cent, nor enough to give the soil a too gravelly character.

The Fort Payne loam is one of the most extensive soil types of the Greeneville area. The principal development is in Greene County, in the limestone part of the valley proper, where the soil occurs in a large area or broad belt extending along both banks of the Nolichucky River. This belt enters the area at the extreme southwestern corner and extends northeast out of the area. There are, however, within the belt small areas of other soils. Some small areas of Fort Payne loam also occur in the limestone belt north of the Holston River, as well as associated with the Fort Payne stony loam, to which soil it is closely related.

The Fort Payne loam occupies the high, rolling ridges and the intermediate valleys. The ridges run in general parallel to each other, and to the valley formations. They are from 100 to 200 feet higher than the valleys. The slopes are, as a rule, gentle enough to permit cultivation, yet on the steeper grades washing is pronounced and cultivation is interfered with.

Because of the rolling character of the Fort Payne loam, the surface drainage is good. Many streams head in the formation, the smaller ones generally following the valleys, while the larger ones cut across the formations. Drainage into sinkholes is also a prominent feature of this soil. Having a clay subsoil, with a more sandy covering to act as a mulch, the soil is retentive of moisture, and is therefore not so droughty as some other of the valley soils.

The Fort Payne loam is a residual soil, and is derived from a limestone formation known geologically as the "Knox dolomite." This formation consists of a series of blue, gray, and whitish limestones and dolomites, the dolomite, however, being the most important in the soil formation. The process of weathering has been mostly a chemical one—that is, the solution of the rock in rain water charged with carbon dioxide. These rocks are highly soluble, containing only 5 to 15 per cent of insoluble matter. The decay is rapid and has gone to a considerable depth. Rock outcrops are seen in only a few places in stream cuts. Portions of the type, however, have small quantities of small cherty fragments which were present in the parent rock and have been left from its decay. The amount, though, is not enough to influence the type materially. Where the cherty fragments do occur in sufficient quantity to influence the character of the soil such areas have been mapped as the Fort Payne stony loam.

The underlying rock is more or less siliceous, and the result of weathering has been the formation of stiff clay, upon which has been concentrated the fine siliceous matter forming the more sandy covering, or soil.

The productiveness of the Fort Payne loam varies greatly over the area. In general it has been cropped continuously and poorly farmed, with the result that its productive power has decreased. Wheat yields on an average about 8 bushels to the acre, although much higher yields are reported. On some of the better farms it will produce as much as 20 to 25 bushels, such yields being secured on the more loamy and heavier phases of the type. In general it is not regarded so highly for wheat as the soils derived from the shales. Corn does fairly well, and seems to be a surer crop than wheat, producing from 20 to 40 bushels per acre, especially on the lower slopes in the small valleys, where there is a greater accumulation of soil. Oats are grown, but not in great quantities, and are fed to the stock in the sheaf. Small quantities of rye are grown. Clovers and grasses do fairly well, particularly upon the improved lands. In some sections on the larger farms large areas are in grasses and used for pasturage. The soil is naturally a little too loose for grasses, but is made more compact by the trampling of the stock. It is considered a good practice to have land trampled by stock, particularly before sowing to wheat. There is much of the land that should be kept in pasture, particularly the steeper slopes, where washing occurs. Formerly considerable quantities of bright tobacco were grown on this type, and some is still grown nearer the mountains, where the sandy covering is deeper.

Commercial fertilizers are used generally on all crops, and are found necessary in order to get even ordinary yields, especially in the case of wheat. The amount of live stock on farms is small, so that little barnyard manure is available. Systematic crop rotations are not generally followed. The land is cultivated chiefly to wheat and corn, with an occasional interval in clover or grass. When the slopes become washed and the land becomes too poor to cultivate the fields are abandoned, and are soon covered by a growth of broom-sedge.

The Fort Payne loam is susceptible of improvement. Having a good subsoil and a loose soil it is easily cultivated, is retentive of moisture and fertilizers, and responds readily to good cultural methods. With a suitable crop rotation and the use of green manuring crops and lime, and with good cultivation, conditions would be greatly improved. Fruit would probably prove successful on this soil. The forest growth consists of oak and chestnut.

The value of the Fort Payne loam varies from $10 to $40 an acre, averaging from $15 to $20.

The following table shows the results of mechanical analyses of the fine earth of typical samples of this soil:

Mechanical analyses of Fort Payne loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11146	¼ mile W. of Buckingham Ford.	Gray loam, 0 to 12 inches.	0.7	3.3	3.9	10.8	12.8	49.8	18.7
11148	3 miles SW. of Greeneville.	Clay loam, 0 to 10 inches.	.3	1.4	9.6	19.6	5.4	24.9	38.7
11149	Subsoil of 11148	Clay, 10 to 36 inches	.1	1.2	4.7	9.2	3.7	14.8	65.7
11147	Subsoil of 11146	Clay, 12 to 36 inches	.0	.7	.8	2.6	2.7	21.5	71.0

FORT PAYNE STONY LOAM.

The soil of the Fort Payne stony loam, to an average depth of 10 inches, varies from a gray to light-yellow or light-brown fine sandy to silty loam, underlain by a yellowish-red clay loam, which soon grades into a stiff, tenacious clay, becoming redder in lower depths. The subsoil is also more or less mottled with white, particularly in the higher lying areas. The color and fineness of the soil give it an ashy appearance and feel. It is sometimes spoken of as "white land."

In the soil and upon the surface are found angular chert fragments, usually small, and varying from 10 per cent of the soil to quantities so large that there is very little soil, the whole being a mass of chert fragments of no value for any crop.

The subsoil, as a rule, is free from these fragments, or has them only in the first few inches. Rock outcrops are also a prominent feature of this type, and, in fact, some areas consist of little else than projecting masses of rock in place.

The Fort Payne stony loam is a valley soil, and is associated with the Fort Payne loam, of which it may be considered the stony phase. Its principal development is in Greene County, along the Fort Payne loam, occurring between the latter and the shale formation as an irregularly shaped belt. Small patches are scattered throughout the area of the Fort Payne loam. A small, continuous strip occupies Big Ridge from Midway to Albany, and another occurs to the north of the Holston River, following a series of high ridges.

The physiographic features of this formation consist of high, broad, rounded ridges, the soils occupying the top, slopes, and intermediate valleys, while in the small areas occurring in the Fort Payne loam they occupy the upper slopes of the ridges, generally those exposed to the east. The ridges are quite marked, rising from 200 to 500 feet above the intermediate valleys. Because of the presence of the chert and rock outcrops, soil washing is, in a large measure, prevented, although in less stony areas washing is pronounced.

From its position and stony character good natural drainage is assured. On the higher situations the water drains off so rapidly that crops suffer for lack of moisture. Sinkholes are numerous, and a prominent factor in the drainage. Some streams head in the formation, although springs are not numerous.

The Fort Payne stony loam is of residual origin, being derived from the weathering of a magnesian limestone or dolomite containing cherty nodules. By the solution of the limestone the cherty nodules remaining are concentrated on and near the surface, so that the resulting soil is stony. The chert, originally black, weathers out white. The size of the fragments varies, but they are usually 1 or 2 inches in diameter and of angular shape. The land of this type is not generally desirable for cultivation, and is mainly left in forest, consisting of chestnut and oak. On the exceedingly stony areas cedar is the principal growth. Some wheat is grown, but the yields are small, as are also those of corn. Areas where rock outcrops do not occupy too much space and where the soil is heavier do well in grass. Bluegrass thrives, and, aside from forestry, pasturage is the use for the type.

On some of the higher ridges peaches have done well, but the orchards are in poor condition at present, and the value of the type as a fruit land can not be definitely stated, although it does seem that with proper methods fruit growing could be made profitable on these lands if climatic conditions were at all favorable.

The value of the Fort Payne stony loam does not exceed $10 an acre.

The following table shows the mechanical analyses of typical samples of the fine-earth portion of this soil:

Mechanical analyses of Fort Payne stony loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11158	1 mile N. of Mosheim.	Silty loam, 0 to 10 inches.	1.3	1.8	1.2	2.3	5.1	68.3	19.7
11160	1 mile N. of Surgoinsville.	Clay loam, 0 to 12 inches.	1.2	1.4	1.3	2.9	9.7	57.2	26.4
11159	Subsoil of 11158	Clay, 10 to 36 inches	.4	.6	.3	.8	2.3	36.5	59.1
11161	Subsoil of 11160	Clay, 12 to 36 inches	.0	.2	.2	.6	3.0	29.0	66.9

The following sample contains more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 11159, 0.79 per cent.

DECATUR CLAY.

The soil of the Decatur clay, to an average depth of 10 inches, varies from a dark reddish-brown loam to a heavy dark loam or clay loam grading into stiff, tenacious, intensely red clay, which extends to great depths.

The largest area of the Decatur clay occurs in the northwestern part of the sheet, occupying the Carter and Stanley valleys in Hawkins County. Numerous small areas occur in Greene County, scattered through the Fort Payne loam and the Fort Payne stony loam. The largest of these areas is that known as the "Horse Creek section," which occupies both banks of the Nolichucky River in the vicinity of Horse Creek. The areas occurring with the Fort Payne stony loam are long and narrow, and in these some rock outcrops are found.

There is one phase of the type occurring as a long narrow strip about one-fourth of a mile wide between the shale and limestone formations in the Stanley Valley, situated in the northwestern corner of the sheet in Hawkins County. In this small area outcrops of the underlying rock, which is a marble, are a prominent feature and occur to such an extent that one-half or even more of the surface is occupied by them. These outcrops appear at the surface as rounded, partly buried bowlders, or in long ledges. Between them the soil is deep and fertile. The marble, which is a metamorphosed limestone, weathers like limestone, the process being one of solution in rain water. This weathering, however, has been unequal, as the marble varies greatly in composition. The softer and more soluble parts have been removed, and the small insoluble residue has formed the soil, while the harder and more insoluble parts have resisted weathing and appear as outcrops. This phase of the type occupies the top and western slope of one of the valley ridges, and a high value is placed upon the land because of the underlying marble, some of which has been quarried in the past.

In the valley proper the areas of the Decatur clay are nearly level to gently rolling, though some of the areas occur on slopes originally occupied by the Fort Payne loam, where this soil has been removed, exposing the subsoil, which, with plowing and the wash from higher slopes, has become loamy. The topography of the Carter and Stanley valleys is gently rolling, and it is in these that the most typical development of the soil is found. Near the mountain slopes the soil is more or less influenced by the sandstone débris of the mountains. The gently rolling character of most of the areas insures good natural drainage, but on the more level situations drainage is assisted by drainage furrows.

The Decatur clay is a residual limestone soil, derived from the weathering of massive limestones. The weathering has resulted in the almost complete decomposition of the underlying rocks, the great depth of the soil formation being shown by cuts and by the rare occurrence of rock outcrops, excepting in a certain phase of the type in one small area heretofore described.

The Decatur clay is recognized as the strongest soil in the area, and is highly esteemed for general farming. Wheat will yield from 10 to 25 bushels to the acre, and even larger yields are reported. The average yield is about 12 bushels. Corn does well, particularly on the lower situations, where the soil is lighter and deeper. The yields range from 25 to 50 bushels per acre. The type is regarded as good clover and grass land, and large quantities of clover and timothy hay are produced. A large acreage is also devoted to pasturage, as live stock, particularly cattle and mules, form an important interest on farms located on this type. Much of this land produces bluegrass.

Farms on the Decatur clay have an appearance of prosperity. They are all fairly well fenced, and improved with good dwellings and barns and other outbuildings. The value of these farms is higher than that of any other of the upland valley soils. The price varies from $15 to $50 an acre, the average being about $25 or $30, depending upon the extent of improvements. The farms on this type generally contain about 200 acres each.

The following table gives the mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Decatur clay.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11140	5 miles S. of Greeneville.	Red heavy loam, 0 to 10 inches.	1.7	4.2	4.3	9.6	12.2	44.6	23.4
11168	1¼ miles SW. of Gillenwater.	Reddish-brown heavy loam, 0 to 8 inches.	3.7	4.1	4.1	7.8	9.5	44.5	26.7
11138	1¼ miles SW. of Blevins.	Brown clay loam, 0 to 12 inches.	1.2	3.2	2.4	4.7	8.1	50.1	30.3
11142	1 mile E. of Greeneville.	Brown heavy clay loam, 0 to 10 inches.	1.1	2.8	2.5	4.1	5.2	47.5	36.8
11141	Subsoil of 11140	Red clay, 10 to 36 inches	.7	2.7	2.8	6.1	7.6	38.4	41.9
11139	Subsoil of 11138	Red clay, 12 to 36 inches	.5	2.6	1.8	4.2	7.6	38.3	44.8
11169	Subsoil of 11168	Red clay, 8 to 36 inches	.3	.8	1.0	3.2	6.5	30.0	58.4
11143	Subsoil of 11142	Dark red clay, 10 to 36 inches.	.4	1.1	.8	1.6	2.9	17.3	75.8

The following sample contains more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 11168, 1.24 per cent.

DEKALB SHALE LOAM.

The soil of the Dekalb shale loam varies from a brown to a yellowish clay loam or clay, having an average depth of 8 inches. The subsoil consists of a heavy yellow clay loam, increasing in clay content with depth until, in the more level situations, it becomes a stiff plastic clay.

Upon the surface and throughout the soil and subsoil are scattered shale fragments, which increase with depth, the subsoil resting upon the broken underlying shale. In some locations, and particularly upon steep slopes, where the soil is removed nearly as fast as made, the formation is little more than a mass of more or less weathered broken shale.

The Dekalb shale loam has an extensive development in this region. Its principal area occurs as a broad belt extending along Lick Creek from near the western boundary northeast entirely across the area. The belt is broadest between Greeneville and Romeo, where it has a width of 8 miles, and gradually narrows until where it leaves the area it is only one-half mile wide. The southern boundary of this belt is irregular, owing to the intermingling of the shale and limestone formations. Extending from Midway to Albany is a high limestone ridge breaking into the Dekalb shale loam area. Some long, narrow belts of the Dekalb shale loam occur in Greene County, mingled with the limestone formations. Three small areas also occur in Hawkins County.

The surface features are those characteristic of shale formations, consisting of a series of rounded hills or knobs without any arrangement, of uniform elevation, with steep sides but smooth contours. Between the hills are narrow, winding valleys, occupied, as a rule, only at wet periods by small streams. Only along Lick Creek and its larger tributaries have the bottoms become wide enough so that flood plains could be developed.

The section occupied by the shale formation is known locally as the "knob belt," because of its characteristic surface features. The long, narrow areas are also marked by a series of broad, rounded knobs, which appear conspicuously contrasted to the limestone formations.

The broken nature of the underlying rock and the steepness of the slopes afford rapid removal of water from the surface soil and subsoil. In fact, the drainage is too rapid, as the soil soon becomes dry, and droughty conditions prevail. The drainage of the principal area is into Lick Creek and its tributaries. These, as a rule, are sluggish streams, and quite deep.

The Dekalb shale loam is a residual soil, derived from the weathering of the underlying shales. These vary from argillaceous to sandy and thin to thick bedded, and all are more or less calcareous. During the uplifts and subsidences to which the valley formations were subjected, the shale formations were turned up on end and greatly distorted and shattered. The process of weathering has been carried on by both physical and chemical forces and has extended to considerable depth. The rocks weather to a yellowish color and the soil formation is shallow. The surface features produced are such as to bring about the removal of much of the weathered product or soil as soon as formed. When there is a chance for accumulation the complete weathering results in a heavy yellow clay.

The principal crops to which this soil is adapted are wheat and grasses. The upland areas are devoted entirely to these crops, while corn is grown on the lower slopes and the narrow bottoms of the valleys. Wheat averages from 8 to 10 bushels per acre, although in favorable seasons much larger crops are obtained. To obtain these yields commercial fertilizers are used, usually at the rate of from 100 to 150 pounds per acre. The fertilizers used are generally the cheap acid-phosphate brands. Without the use of fertilizers, which serve to start the crop, good stands can not be obtained with the present condition of the soil. The wheat, however, is of superior quality.

The grasses grow well when care is given to the working of the land, but much of this land has been farmed so carelessly and allowed to wash so badly that it is difficult to get a good stand. Timothy is produced, and also clover. The hay is almost all baled and sold. After a crop or two has been removed the fields are pastured. It is reported that for the last few seasons it has been difficult to get a good stand of grass. It starts well, but when a dry season comes in midsummer it is burned out.

Corn does not do well because of the heavy texture and shallowness of the soil and its tendency to droughtiness. As corn does not do well on the uplands, a rotation with a cultivated crop can not well be followed. It is carried out by some, however, the corn being followed by wheat for two years, and then by grass for hay, finally pasturing a few years. The soil seeds to bluegrass naturally, and is therefore adapted to grazing.

Conditions on this type could be greatly improved if more live stock were kept and the manure put back on the land. The soil is retentive of fertilizers. Lime has proved beneficial, but very little is used. The physical condition could be greatly improved by the use of green manuring crops.

The farmers on the "slate lands," as the Dekalb shale loam is called, are fairly prosperous. The farms are all well fenced, and good dwellings and outbuildings are seen. The farms, as a rule, are large, and are valued at from $10 to $30 an acre, the average price lying between $15 and $20.

The following table gives the results of mechanical analyses of the fine earth of typical samples of this soil:

Mechanical analyses of Dekalb shale loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11156	4 miles NW. of Greeneville.	Brown clay loam, 0 to 8 inches.	10.4	10.5	4.1	5.7	5.8	34.7	28.6
11154	1½ miles E. of Mosheim.	Brown clay, 0 to 7 inches.	.4	1.8	1.9	2.6	2.1	38.5	52.1
11155	Subsoil of 11154	Yellow clay, 7 to 18 inches.	4.3	7.3	3.7	6.2	6.2	27.5	44.5
11157	Subsoil of 11156	Clay, 8 to 18 inches	1.7	2.5	1.5	3.1	6.5	30.5	54.2

The following sample contains more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 11155, 0.90 per cent.

FORT PAYNE CLAY.

The soil of the Fort Payne clay, to a depth of 7 inches, consists of a clay, which when moist is sticky and of a brownish color, but when dry becomes gray or slate colored. The subsoil is a yellow clay, which quickly changes with depth to a stiff, plastic yellow clay having a greasy feel. The depth rarely exceeds 20 inches, the material resting upon the weathered and more or less broken underlying rock.

On the steep slopes the soil has been removed or partly removed by erosion, and the subsoil is exposed. Small shaly fragments, of varying quantity and more or less decomposed, are found upon the surface and in the soil and subsoil, and where erosion has been active, as on the slopes, the soil formation consists of the decomposed fragments, which form a plastic clay, retaining the structure of the rock from which derived. Upon plowing land in this condition it breaks into little blocks and becomes cloddy. The subsoil exposed in washes and cuts has a greenish-yellow color, and checks in blocks upon drying. The soil also shrinks into blocks upon drying, and large cracks are formed. Besides the smaller fragments a prominent feature is the slabby pieces of shale and shaly limestone scattered over the surface, the quantity, however, rarely being sufficient to affect cultivation materially. Outcrops of the underlying rocks occur on the eroded slopes and the tops of ridges.

The Fort Payne clay occurs as long, narrow areas in the ridge district of the valley section, the greatest development being in the strips bordering and immediately south of Bays Mountains and along the Holston River. Most of these strips are continuous, varying some in width, and extend across the area in a northeast to southwest direction, continuing on out of the area. The type occupies the narrow intermediate valleys as well as the lower slopes of the mountains. Some of these valleys, or portions of them, are gently rolling to moderately hilly. Nearer the mountains, or on what might be termed the " lower slopes," the formation is hilly or knobby. The area along the Holston River is extremely rough, consisting of rounded knobs and irregularly shaped ridges which rise rather steeply from 200 to 300 feet above the valleys between them.

The drainage of the Fort Payne clay is mostly effected from the surface, as the subsoil is more or less impervious, although there is some underdrainage through the broken underlying rocks.

The Fort Payne clay is derived from the weathering of shales varying from sandy to thick-bedded calcareous shale and shaly limestone. The formation occurs with the sandstone, the more sandy shales lying next to the sandstone, the effect of which is shown in the soil. The process of weathering has been carried on both by physical and chemical forces, the broken fragments decaying in place to form the soil. These rock formations stand vertical or nearly so, but the resulting soil is shallow, being constantly reduced by erosion. Often the rock is exposed or is close to the surface. In the degradation of these formations slabby pieces a foot or more long and an inch or more in thickness, representing the less soluble parts, have been left on the surface.

In a small area, less than 2 square miles in extent, in the extreme northwestern corner of the survey in Hawkins County, there is a noticeable variation in this type of soil. Outcrops of shaly and massive limestones occur, and slabby fragments of the former are found strewn on the surface, while the outcrops of the latter are so prominent in some localities as to leave little land for cultivation. These outcrops appear most commonly in long, parallel ledges. Where the limestone has entered into the soil formation, the subsoil has become reddish, and red clay is found beneath. This phase of the Fort Payne clay, owing to its hilly and steep topography, its droughty nature, and the outcropping of the rock or its nearness to the surface, is used almost exclusively for pasturage. Bluegrass grows upon it and affords good pasturage, except in times of drought.

The Fort Payne clay is known locally as "Redbud land," a name which in this part of Tennessee is generally applied to heavy soils on which redbud grows. This is the heaviest soil of the Greeneville area. The land is said to hold water—that is, the subsoil is always moist, yet in dry times plants suffer from lack of moisture, the close texture retarding its passage to the growing plants. When wet the soil is exceedingly sticky and intractable, and upon drying it bakes hard and cracks. When worked wet clods are formed, which are difficult to reduce; hence it is necessary that the land should be worked when in proper condition to insure good tilth and to obtain the best results.

The Fort Payne clay is considered one of the strongest and most productive soils of the area. It is best adapted to those crops which do best on a heavy soil, and can withstand drought or be harvested before the summer season is far advanced. These comprise the grain crops and grasses. Of the cereals, wheat does best, yielding on an average from 10 to 15 bushels to the acre. These yields are often exceeded, however, and should be if the land is well prepared. The more level or gently rolling to moderately hilly lands are generally desired, and these farms in the small valleys, such as the Butcher Valley, are noted for their productiveness. The extremely hilly lands, though too steep for grain farming, do fairly well for pasturage, as bluegrass grows upon them naturally. Nearly all the land of this type is cleared and devoted to either grain or grass. Clover also thrives upon this soil, but for the last few years it has been difficult to get good stands because of the unfavorable seasons. Long droughts in summer have burned the clover and grasses out, or else unfavorable weather has retarded the growth of the plants, so that the stand was not strong enough to go through the summer. On the lower slopes, where the soil is deeper and more loamy, good corn crops are produced and also excellent crops of timothy hay.

This soil is retentive of manures and is much improved by the use of barnyard manure and green manuring crops. Lime is also beneficial in improving the structure of the soil.

The conditions on this soil are similar to those on the Dekalb shale loam. The value of the land is about the same, or possibly a little higher.

The following table gives the results of mechanical analyses of the fine earth of typical samples of this soil:

Mechanical analyses of Fort Payne clay.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11162	1¼ miles N. of Gillenwater.	Brown clay loam, 0 to 8 inches.	0.8	1.9	1.0	2.2	14.2	47.1	32.9
11150	¼ mile S. of Strahl	Brown clay, 0 to 8 inches.	1.3	3.8	2.6	3.2	1.7	38.3	49.1
11152	2 miles W. of Baileyton.	Brown clay, 0 to 7 inches.	1.0	2.1	1.2	2.6	2.0	33.0	58.2
11163	Subsoil of 11162	Clay loam to clay, 8 to 20 inches.	1.8	3.8	1.7	2.5	16.5	44.4	30.0
11151	Subsoil of 11150	Yellow clay, 8 to 24 inches.	.7	3.3	2.6	4.4	2.6	30.9	55.2
11153	Subsoil of 11152	Yellow clay, 7 to 16 inches.	.8	1.5	1.1	1.7	1.0	31.7	62.7

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 11152, 0.7 per cent; No. 11153, 6.5 per cent; No. 11151, 5.7 per cent.

FORT PAYNE CLAY LOAM.

The Fort Payne clay loam, to an average depth of 10 inches, consists of a compact loam to almost silty loam. It has an ashy appearance and feel, and the color ranges from gray to light yellow. The subsoil is a heavy yellow clay loam, grading quickly into stiff, sticky, impervious yellow clay, which in the lower depths is often mottled with red. The depth of soil and subsoil usually exceeds 36 inches, but in places shaly material is found near the surface. The subsoil is of an impervious nature, being so close that the movement of moisture is retarded, with the result that in dry times the soil is very droughty and crops suffer greatly. For this reason the type is not generally desired as farming land.

The Fort Payne clay loam occurs in two areas in Greene County. The principal one is found between Caney Branch and Cedar Creek, where it has the greatest development, coming into the area below Sirenburg and extending northeast, crossing the Nolichucky River, and finally ending at Richland Creek. The other area, which is probably a disconnected part of the one described, occupies the hills to the west of the town of Chucky.

The type occupies high hilly to gently rolling lands. The hills resemble those of the shale formations, but have longer and gentler slopes. The impervious character of the subsoil does not admit of underdrainage, so that the greater part of the rainfall runs off the surface. On the more level uplands swampy conditions prevail to some extent.

The Fort Payne clay loam is a residual soil, derived from the weathering of a series of rocks consisting of sandy to argillaceous calcareous shales, shaly limestones, and impure limestones. The more sandy product occupies the surface, while the clay forms the subsoil. The weathered shale is found in road and stream cuts, and the subsoil often retains the structure of the original rock until disturbed. Upon the surface, and especially on the lower slopes, are found rounded "niggerheads" of cherty material. These, however, do not occur in sufficient quantity, except in a few small areas, to interfere with cultivation.

This land is not generally desirable, and though much of it has been cleared a large part is still in forest. The cleared portions afford some pasturage. Wheat produces from 6 to 10 bushels per acre. The type is not suited to corn at all, except on the lower situations. If seasons are favorable good stands of grass can be obtained. The land is difficult to work, and it is said to be necessary to break it while in a moist condition, for the material, though containing some coarse sand, works like an extremely heavy soil. When wet it puddles, and when dry it becomes very hard and breaks up into lumps. The roads are clayey, and when wet are very slippery, travel being impossible when they are very wet.

The value of land composed of this type of soil as a rule does not exceed $10 an acre.

The table following gives the results of mechanical analyses of the fine earth of typical samples of this soil.

Mechanical analyses of Fort Payne clay loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11124	2 miles SE. of Caneybranch.	Loam, 0 to 10 inches	6.7	5.3	2.8	6.5	9.1	52.7	16.8
11122	5 miles S. of Greeneville.	Loam, 0 to 8 inches	4.9	5.2	2.6	5.5	9.7	53.0	19.1
11123	Subsoil of 11122	Mottled clay, 8 to 36 inches.	.2	.5	.5	2.2	4.7	40.3	51.8
11125	Subsoil of 11124	Clay, 10 to 36 inches	2.4	2.5	1.3	3.0	4.2	28.1	58.5

CUMBERLAND LOAM.

The soil of the Cumberland loam consists of a gray, slightly sandy loam, averaging 10 inches in depth, somewhat silty in texture, and having an ashy appearance and feel. The texture, however, varies. In some localities the sand particles become coarser and there is less silt present. The subsoil is a yellow, slightly sandy loam of similar texture to the soil, but somewhat more compact, sometimes becoming a little heavier in lower depths. The depth of the subsoil generally exceeds 36 inches, but sometimes it is less, the underlying shale coming to within 24 inches of the surface, in which case the lower part of the subsoil becomes clayey from the shale. Rounded, waterworn gravel are found on the surface in some areas, and sometimes beds of gravel occur in the formation. In general, however, the type is free from stones. It is locally known as "white land."

The Cumberland loam is found along the Holston River, occurring as a second terrace, which is either level or slopes gently toward the river. It is a sedimentary soil formation, laid down by the Holston River at some earlier stage in its development. It is deposited over a shale formation, which outcrops in road cuts and is sometimes but little below the surface.

The Cumberland loam is considered a "thin" soil, and hence is not generally cultivated, not being so desirable as the adjoining areas of heavier soils and first bottoms. It is largely left in forest, forming the wooded portion of the farms along the river, and valued for its supply of firewood and lumber. It is a leachy soil, and can not be readily improved, but does well for garden vegetables. It produces a good quality of bright tobacco, but at present no tobacco is grown, mainly because of the ruling low prices.

These lands are generally a part of bottom farms, and no particular value is placed upon them.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Cumberland loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11164	1 mile S. of Spears...	Slightly sandy loam, 0 to 10 inches.	1.0	4.9	5.3	17.8	17.8	44.5	8.7
11166	¼ mile E. of Chissolms Ford.	Slightly sandy loam, 0 to 12 inches.	.4	2.0	2.2	13.2	24.9	48.3	8.7
11165	Subsoil of 11164	Slightly sandy loam, 10 to 30 inches.	1.2	5.9	5.5	17.9	16.8	39.9	12.5
11167	Subsoil of 11166	Yellow loam, 12 to 36 inches.	.2	1.4	1.4	9.9	20.4	48.6	17.7

DEKALB SILT LOAM.

The Dekalb silt loam, to an average depth of 10 inches, consists of a gray to light-yellowish compact loam, or clay loam, which is quite silty. It has an ashy appearance and feel. The subsoil is a yellow silty clay, commonly mottled with white in the lower depths. This rests usually upon a yellow clay, which in turn grades into shale. Generally this clay foundation is reached at depths greater than 36 inches, but in some places it rises to within 20 inches of the surface. Broken, thin-bedded, sandy shales are also found near the surface on the slopes and tops of knolls.

The type occurs as a narrow strip between the Dekalb shale loam and the Fort Payne clay, extending across the area in a northeasterly direction, and nowhere exceeding a width of a little over a mile, the widest part being between Romeo and Baileyton. It occupies nearly level to gently rolling lands, and has become known locally as "flat-woods," the greater part of it being forested with oaks.

The type is probably of residual origin, being derived chiefly from very fine sandy shales. These shales are found exposed in road cuts, but fragments seldom occur upon the surface or in the soil, the degradation of the rock being complete. There is a possibility, however, of its being a sedimentary soil, in the form of an old terrace, or that it is a wash from the mountains together with material derived from shale formations.

The position of the Dekalb silt loam does not insure good surface drainage, as much of it is quite level, and as underdrainage is prevented by the impervious character of the clay found beneath, the type is cold and wet and works like a heavy soil.

The land of this soil is considered "thin," but it is said to be easily improved. It is retentive of fertilizers, and is greatly improved by the use of barnyard manure and green manuring crops. It can, therefore, be made to give fair yields. Wheat and grass are the principal crops. The former does not exceed 8 bushels per acre, as a rule, though larger yields are occasionally obtained. The grain, however, is of good quality. The type does fairly well in grass.

The following table gives the results of mechanical analyses of typical samples of this soil:

Mechanical analyses of Dekalb silt loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11120	1 mile E. of Baileyton.	Silty loam, 0 to 10 inches.	0.4	0.8	0.9	2.3	9.5	62.2	23.7
11118	1¼ miles E. of Romeo.	Clay loam, 0 to 8 inches..	.5	1.7	.8	1.4	2.6	65.0	28.1
11121	Subsoil of 11120	Clay, 10 to 36 inches	.3	.5	.6	1.4	6.9	53.1	37.2
11119	Subsoil of 11118	Clay, 8 to 36 inches	.2	.5	.2	.7	2.6	55.3	40.4

DEKALB STONY LOAM.

The Dekalb stony loam is a mountain type of soil and the only one occurring on the mountains in the Greeneville area. The soil consists of a gray to yellowish medium to coarse sandy loam, with an average depth of 8 inches. The subsoil is a yellow sandy loam rarely exceeding a depth of 20 inches, and at that depth resting upon a mass of broken sandstone, or, as on lower talus slopes near streams, on rounded, waterworn sandstone bowlders. Upon the surface and throughout the soil and subsoil occur angular and subangular sandstone rocks, their character and quantity varying in different locations. The greater number of loose bowlders is found on the lower slopes, as on the long talus slopes of the Bald Mountains toward the Nolichucky River. Here the quantity is often sufficient to preclude cultivation. However, there are areas with only a small proportion of rock fragments present. Such areas occur on the long talus slopes mentioned above, and represent the fine material or sand which has been washed out of the sandstone formation. Other less stony areas occur on the top and lower slopes of Bays Mountain, in the ridge district of the valley, where the rock is somewhat different and has weathered more uniformly. In places where the red sandstone has entered into the soil formation the type varies in color and to some extent in texture, being brown or red and a little finer, while the rock fragments are small and not quite so numerous. The area, however, of this variation from the general type is small.

The Dekalb stony loam is one of the extensive soil types of the Greenville area. It is found developed principally in two sections of the area, occurring in both physiographic divisions. One of the areas is large and continuous, and is situated in the extreme southeastern part of the sheet, covering the Bald Mountains; the other development is the principal feature of the ridge district in the valley, occurring as a long, narrow area occupying the tops and upper slopes of the ridges and mountains of that section.

As the Dekalb stony loam covers the mountains, its surface features are those of the tops and slopes of these mountains. As a rule the tops are narrow and stony. One exception is the main ridge of the Bald Mountains, a part of which has a broad rolling top, with a soil somewhat loamier than the general type. This part is known as the "Beech Bottoms," from the beech growth there. Another exception occurs in the ridge district, in which the rocks have weathered in a series of broad, rounded domes occurring at regular intervals, and to these has been applied the name of "comby ridges."

The upper slopes, as a rule, are abrupt, often consisting of high, precipitous cliffs or very steep slopes with outcrops of rock, or with large bowlders scattered thickly over the surface. Lower down the talus slopes become less steep, but still have large quantities of stones. The largest talus slope is that of the Bald Mountain, and is the most important part of this type agriculturally.

Because of its topographic position, its sandy and stony character, and the underlying mass of broken rock, the drainage of this soil is rapid and thorough.

As has probably been inferred from the preceding description, the Dekalb stony loam is a residual soil. It has been derived from the disintegration of a variety of sandstone rocks, which consist of sandstones varying from fine to coarse to moderately coarse conglomerates, and to quartzite and sandy shales. These are all more resistant to weathering than any of the other rock formations of the region, and hence form the higher parts of the area and the mountain cliffs. The bowlders and rock fragments are angular to subangular, except on the lower talus slopes, where the fragments have been waterworn and rounded.

The greater part of the Dekalb stony loam is of no agricultural value. The tops and slopes of the Bald Mountains and some parts of the mountains in the ridge district are inaccessible, besides being too steep and stony for cultivation. The soil, in general, affords only a light forest growth, consisting of oak, chestnut, and some pine, and even this is of no value because of its inaccessibility. In some of the ravines, where the soil is richer, heavier growths are found, consisting of pine, hemlock, and hardwoods, and where accessible these are of value. The value of the mountain lands depends almost entirely upon the forest growth, though they are also of some value as a range for cattle and sheep.

The lands that are capable of cultivation are not very productive. The texture of the soil makes it leachy, and it can not be permanently enriched or brought to a much higher state of cultivation. The lower gentle talus slopes are cultivated, the principal crop and the money crop on this type being tobacco. This is a bright yellow tobacco used for smoking and chewing, and is generally put up in the form of a twist. The better grade is used as plug or twist wrappers. It is a strong tobacco, and its quality can not be considered the best. Yields are generally about 500 to 600 pounds to the acre, though larger yields are sometimes obtained. Commercial fertilizers are used in all cases. A medium quantity brings about the best results. The quality of the tobacco grown on the richer soils is not considered so good as when grown on the thinner soils with the use of fertilizers. The tobacco is flue cured and sold on the Greeneville market. The prices obtained are low, making the growing of tobacco almost unprofitable, so that the growers are decreasing the acreage, and many are abandoning it entirely. The type is not well adapted to farm crops. Of the cereals, rye does the best, but the yields are small. Corn gives low yields and does better on the stony parts that can be cultivated, because of better moisture and temperature conditions. Vegetables and small fruits do well. The soil is adapted to peach culture, particularly on the slopes, but the market facilities are not such as to warrant the extensive growing of the fruit, unless it should be for drying or canning.

The following table gives the results of mechanical analyses of typical samples of the fine earth portion of this soil:

Mechanical analyses of Dekalb stony loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11126	Blairsgap	Medium to fine sandy loam, 0 to 8 inches.	0.2	3.1	18.6	50.9	10.5	11.7	5.0
11134	5 miles E. of Whig	Coarse sandy loam, 0 to 8 inches.	4.1	16.6	12.9	20.2	7.5	24.2	14.1
11128	2 miles W. of Gillenwater.	Brown sandy loam, 0 to 8 inches.	1.7	6.5	6.1	13.7	13.5	42.7	15.7
11127	Subsoil of 11126	Brown sandy loam, 8 to 20 inches.	.5	2.8	16.2	48.4	12.4	14.7	4.9
11135	Subsoil of 11134	Coarse sandy loam, 8 to 20 inches.	5.0	16.2	11.6	18.8	7.7	23.2	17.6
11129	Subsoil of 11128	Yellow loam, 8 to 20 inches.	.6	4.7	6.0	13.0	18.9	33.2	23.6

MEADOW.

The term Meadow is applied to all lands occurring as first bottoms along the larger stream courses. These bottoms are flood plains built up by the streams at times of high water by the deposition of the earthy materials carried in suspension; and as the sources of the material vary the soils are in consequence a heterogeneous mixture, being derived from the wash of slopes adjacent to the place of deposition, and also from material brought down by the flood from sources upstream. These soils vary from sandy to silty loams or loams to silty clay loams. The lands are all subject to annual overflow, and are wet during a large part of the year.

The Meadow lands occur in two principal phases in this area, depending upon the source of the material, the texture varying accordingly. One phase occurs in the stream bottoms in the limestone areas and the other along the streams flowing through the shale formation. The first phase is not very extensive, as the streams in the limestone formations are still cutting their channels and not building flood plains. Narrow bottoms occur along the Nolichucky and Holston rivers and their larger tributaries. Areas along small streams were too small to show on a map of the scale used.

The soil of this phase varies from a brown sandy loam to a loam or silty loam about 10 inches in depth, underlain by the same material, but more compact and possibly somewhat heavier, to a depth of several feet. These bottoms have been greatly damaged in the last few years by freshets, which carry down great quantities of sand and gravel and deposit them over the surface, often ruining the land for farming purposes. These freshets are increasing in severity as the forests are removed, and especially in the mountains, where the water now rushes off the cleared slopes, where formerly the forest growth held it in check. Where these bottoms are so situated that they are not damaged by the freshets they are desirable lands, and attain a value of $100 an acre.

The principal crop grown is corn, which produces on an average 50 to 60 bushels an acre, though cases are not rare where 100 bushels have been obtained. Large crops of timothy can be obtained, but this is not so certain a crop as corn, as it is damaged by the deposits. Wheat grows too rank and is injured by freshets.

The other phase of the Meadow occurs along Lick Creek and its tributaries. Lick Creek follows a winding course through the shale formation, and wide flood plains have been built up by it, and also along its tributaries. These are all deep, sluggish streams. Lick Creek flows nearly across the central portion of the area, and bottoms extend along its whole length, while outside the area, on its lower course, these bottoms become still more extensive and form the most important agricultural section of Greene County. The sediment forming these bottoms is the wash from the surrounding shale lands. The soil of this phase, to an average depth of 10 inches, varies from a dark-brown heavy silt loam to a silty clay loam, underlain in the first instance by the same material, somewhat more silty and compact and of a lighter color, this being underlain by a heavy silty clay loam, which in its lower depths grades into a yellow, plastic, impervious clay. This phase is locally known as "gumbo land," and occurs back from the streams in lower situations. Unlike the bottoms along the Nolichucky and Holston rivers, deposits of sand are here desirable, because of their beneficial influence in improving the texture of the soil.

The Lick Creek bottoms are too heavy-textured for corn, yet fair yields can be obtained. They prove much better adapted to the smaller grains and grasses, and particularly to the latter. Large yields of wheat are obtained, but wheat is apt to lodge. Timothy, at present prices, is the best crop, and the one to which the greater portion of the bottoms is devoted. It yields 2 tons or more of hay to the acre. Greene County has long ranked as one of the leading hay counties of the State, and it is on these bottoms that the large quantities of hay have been obtained in the past.

These bottoms, being wide and flat, are more or less wet, and when other crops than grasses are to be grown drainage is essential. This is generally done at present by ditches and open furrows. However, some of the bottoms are underdrained by tiles, and their use will no doubt increase. On the extensive bottoms below and outside of the limits of the survey drain tiles are in general use.

As stated before, the Lick Creek bottom lands are the most important agriculturally in the area, and the owners are prosperous. These lands have the highest assessed value of any in the area, the valuation being about $75 an acre. When sold farms bring $100 or more an acre.

AGRICULTURAL CONDITIONS.

The area included in the survey, as already stated, is a part of the earliest settled portion of Tennessee, and the lands suitable for cultivation have been cultivated for a long time. General farming has been followed since the earliest times, with corn and wheat as the principal crops. These crops have been grown continuously, with the result that some of the lighter valley soils have decreased in productiveness. To such an extent has this gone that fertilizers are now considered necessary for all crops. Many old fields are to be seen, thrown out of cultivation because of unproductiveness. These are gullied by washing and covered by a growth of broom-sedge instead of bluegrass which naturally spreads over limestone soils in this part of the United States.

While Tennessee was the leading corn-producing State of the Union, and for some time after corn and wheat were profitable crops, and the raising of live stock was also an important industry, land values were rising, and the farmers are said to have been prosperous; but in more recent times the production of corn and wheat has not been so profitable, with the lower prices and the decreased productivity of the soils; while with the fall in the price of beef the raising of live stock has declined somewhat. As a consequence the farmers have not been so prosperous, and land values have decreased.

The agricultural interests are confined to general farming, with need of a ready and profitable money crop. The area affords a variety of soils, of wide adaptation and varying productiveness, and conditions over the area vary accordingly. On the Lick Creek bottoms and the "red limestone soil," or Decatur clay, the greatest degree of prosperity is shown. The former is considered the most important section of Greene County and also of the area. The Lick Creek bottoms, or Meadow lands, are the highest in value in the county. The farmers are prosperous and wealthy. They invariably make large crops and all raise more or less live stock. They have good and even pretentious dwellings, with large barns and outbuildings, while the farms are fenced and in many cases underdrained by tiles.

The Decatur clay ranks next in importance to the Lick Creek section. Owners of farms on this type of soil are likewise prosperous. They, too, have good dwellings, barns, outbuildings, and fences. Good yields of the cereal and grass crops are obtained, and a considerable amount of live stock is kept.

The extremely cherty limestone soils are not desired and are of little value. They are left in forest, consisting of oak and chestnut, or where farmed at all it is by the poorer classes.

The sandy limestone soil (Fort Payne loam) shows the effects of continuous cropping in the appearance of the fields and growing crops. The fields are not receiving the care they should and many of the slopes are washing. With but few exceptions no improvements are being made. The houses are small and plain. The barns are small and often mere sheds, and provision is not generally made for housing live stock, except the horses. It is claimed, however, that the appearance of the farms does not indicate entirely the financial standing of the owners, as many are said to be well to do. Then, too, many of the farms are rented, which accounts in great measure for the lack of improvements.

There is a large extent of shale or "slate" soils in the area, and on these are the wheat farms, wheat being the main crop, and one to which these soils are well adapted.

The mountain soils are thin, and generally too steep and stony to cultivate. They are mostly forested, and the value of the land is very low. The people living on them manage to make a living, however, their money crop being bright tobacco.

According to the Twelfth Census, of the total number of farms in Greene and Hawkins counties two-thirds are operated by the owners. The renting is chiefly on the share basis. The better farms are managed by the owners, who hire the necessary help. There are quite a number of large farms in the area, but according to the authority just quoted the average size of farms for the two counties named is 85 acres.

Labor is both white and colored. The laborers generally prefer to work the land on shares rather than by the day. The negro population is small.

Corn and wheat are the principal field crops of the Greeneville area, corn being the leading crop. In Hawkins County the acreage in corn in 1899, according to the Twelfth Census, was 41,630 acres, which is equal to that of all the other crops combined. The acreage in wheat was one-half that in corn. In Greene County there were 50,000 acres in corn, with an acreage of wheat only a few thousand acres less.

The large extent of shale soils in Greene County accounts for the large acreage of wheat. Oats are also grown, and the acreage is increasing. In Hawkins County the acreage of oats, according to the Twelfth Census, was about one-third that of wheat, while in Greene County the proportion is only about one-eighth.

The grasses and clover are also important crops. Of the grasses cut for hay timothy leads. It is the principal crop on the Lick Creek bottoms, and large yields are obtained. With the prices received for hay this crop is remunerative. Clover succeeds on most of the soils when the season is favorable. It also is cut for hay. The millets and Hungarian grasses are also grown and are gaining in favor. Great difficulty has been experienced in the last few seasons to get stands of grasses and clover, the climatic conditions having been unfavorable. Blue grass seeds naturally in all the limestone and shale soils, and is the pasturage depended upon for live stock.

The need for a money crop has always existed. Tobacco was taken up in the eighties, and its cultivation became general. For a few years the crop proved quite profitable; but at the low prices of the last few years tobacco can not be produced with much profit.

It is still an important crop, although its production is decreasing, and is now restricted to the white soils of the mountains and the talus slopes. A much better grade is grown on these higher soils than on the limestone soils. The latter, however, produce Burley tobacco of fair quality, though very little is being grown at present. The production of tobacco in Greene County in 1899, according to the Twelfth Census, was 517,150 pounds, and in Hawkins County, 60,050 pounds. The amount was much less than had been raised formerly, and the amount now is probably still less than in 1899. The product is chiefly a bright yellow tobacco, although some Burley is produced. The former is used in the manufacture of granulated smoking tobacco and chewing tobacco. The better leaves grade as light plug wrappers. There are in Greeneville several tobacco factories which manufacture the tobacco for the market. Commercial fertilizers are necessary to grow a crop. The amount used is generally 200 or 300 pounds to the acre, with an average yield of probably 500 to 600 pounds of tobacco. The tobacco is flue cured.

All the tobacco from this section and western North Carolina is sold in open auction at Greeneville. The buyers are the local manufacturing companies, as well as representatives of the larger tobacco companies. The amount sold at present is about 1,000,000 pounds annually, but as much as 3,000,000 pounds in one year has been handled through this market.

Some sorghum cane is grown, but the product is consumed at home. Both sweet and Irish potatoes are grown, but only for home use. A relatively small quantity of broom corn is being raised. An effort is being made to increase the acreage of this crop, and it should prove a profitable one. Already a broom factory is in operation, which at present has the material shipped in, but is planning to use home-grown material in the near future.

The adaptability of a number of the soils to fruits is unquestioned. Good fruit has been grown, but not on a commercial scale. On similar soils in Virginia fruit culture has succeeded. Peaches do well on the Dekalb stony loam, and the tops and slopes of the mountains in the northwestern part of the area would be desirable locations. With the poor roads, long haul, and lack of good railroad facilities, however, this crop would hardly pay unless the product should be canned. The cherty hills of the valley would also produce good peaches. Of the fruits, apples would probably succeed the best and be most profitable. Aside from the inadequate shipping facilities, the chief drawback to fruit culture in this section is the occurrence of unseasonable frosts; but it is claimed that even if a full crop were obtained only every third year apples would still pay better than the field crops on some of the soils.

Small fruits would no doubt succeed on the sandy soils, but they would have to find a market outside the area.

As a general rule no systematic crop rotation is followed, except by a few of the better class of farmers. The rotation with them consists of corn, followed by wheat, and then by clover or grass, which, after a couple of crops of hay, is left as pasture. Usually corn and wheat follow each other, with several crops of corn before a wheat crop is taken. On the shale or "slate" lands corn hardly enters into the rotation at all, as the soils are not adapted to its growth. On these soils grass or clover follows the wheat, of which two or more crops are taken before the soil is seeded to grass. It would be much better if a systematic and well-adapted crop rotation were followed on all soils. The use of leguminous and green manuring crops would do much to improve all the soils. No particular efforts are made to make and save the barnyard manure for use on the fields. On the other hand, the use of commercial fertilizers is general and is increasing. Fertilizer is used generally with wheat at seeding time to help it start, and on the poorer soils with corn. Lime has a beneficial effect on all the soils, but it is used hardly at all, though it can be obtained easily.

Improved farm implements are used, but their introduction is of recent date.

The transportation facilities of the area are fair. The Southern Railway crosses the area, giving direct connections to the north and south. A branch line from Bulls Gap, just a few miles outside the area, runs to Rogersville, affording an outlet for the northwestern part of the area.

Throughout the area the country roads are poor and are not kept up as they should be. The roads are of clay and during the summer season become hard and smooth and excellent for travel. During the winter, however, when they become wet and deeply rutted they are almost impassable. The roads could be easily improved, for there is plenty of road metal to be obtained from the limestone deposits. Within the area there is less than 2 miles of macadamized roads. The matter of good roads is being agitated, however, and no doubt better ones will soon be built. They would assist materially in improving the conditions of the area as a whole. Many of the roads should be reestablished, taking advantage of the topography. As they are now many of them go over hills that could be avoided.

The local markets for products are limited. As stated before, Greeneville is the bright tobacco market for east Tennessee and western North Carolina. For a market for any special product recourse must be had to shipping, and northern cities offer the best markets. At the present time the shipment of poultry and eggs from East Tennessee is quite large and is an important source of revenue to the farmers. The railroad offers good facilities for shipment, running special express trains weekly to northern cities for that purpose. With markets opened up the demands are greater, and prices are now probably double what they were formerly.

One of the natural advantages of the area is the water power afforded by its numerous streams, of which use is made to run the many grist and saw mills. The people have the advantage of a complete system of rural free delivery of mail, every community being reached by the service. Rural telephone service is also being rapidly extended. The educational advantages in the area are good. One of the oldest educational institutions in the State is still in existence in Greene County.

The water supply is plentiful, owing to the great number of springs scattered over the area. These are largely limestone, except those of the mountains, which are freestone, more or less impregnated with iron.

Its proximity to the mountains and the generally healthful climate makes the area a desirable place to live, and there are many summer resorts, which are well patronized.

SOIL SURVEY OF WARREN COUNTY, KENTUCKY.

By **THOMAS D. RICE** and **W. J. GEIB.**

LOCATION AND BOUNDARIES OF THE AREA.

Warren County is situated in the south-central part of Kentucky and is included within the parallels of 36° 48′ and 37° 11′ north latitude and the meridians of 86° 10′ and 86° 42′ west longitude. The county has an irregular outline, but is approximately hexagonal in shape. It is bounded on the north by Edmonson County, on the northwest by Butler County, on the southwest by Logan County, on the south by Simpson County, and on the east by Allen and Barren counties.

Bowling Green, the county seat, is the largest town of the area, having a population of about 8,000. Smiths Grove and Woodburn are prosperous hamlets. There are no other villages of any size in the area.

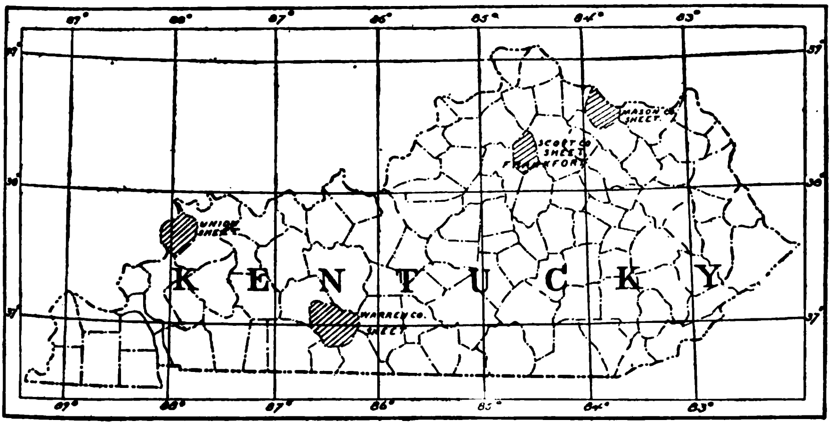

FIG. 21.—Sketch map showing location of the Warren County area, Kentucky.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The first settlers of this part of Kentucky were of the daring and restless class of pioneers that found life in the more thickly settled States too confining, and pushed out in this direction to find a new home. These frontiersmen, finding game plentiful, and being engaged in almost constant warfare with the Indians, had, up to the time of the Revolutionary war, done little to develop the agricultural resources of the region. The first permanent settlement was made at the present site of Bowling Green, and the historical records of Warren County show that the famous backwoodsman Daniel Boone was one of the early settlers of this region. The increase in population was very slow until the close of the Revolutionary war, after which immigration became more rapid.

In 1796 Warren County, with its present boundaries, was formed from a part of Logan County. Four years later the population of the new county was 4,686. Bowling Green was made the county seat, and in 1810 was incorporated. The greater part of the permanent settlers came from Virginia and North Carolina. They found the northern and western parts of the county well timbered with oak, hickory, red cedar, and other valuable woods, while the whole southern and central part of the county was bare of trees. At first the treeless lands, or "barrens," as they were called, were avoided by the settlers, as it was supposed that the lack of forests was due to some deficiency in the soil. It was soon found, however, that corn and tobacco would yield better in the barrens than in the forested areas, and the former, being more easily brought under cultivation, were quickly taken up by progressive planters.

The course of agricultural development in Warren County has been uneventful since the first settlement. The settlers from Virginia, having grown tobacco before their emigration, took up this industry in their new home with profitable results. Corn and wheat were also grown at an early date. As soon as conditions would permit, the raising of live stock was begun, and this industry has been continued with success ever since.

The conditions which prevailed in this part of Kentucky prior to the civil war were those common to nearly all other southern communities. On the limestone soils of the southern and western parts of the county it was found profitable to employ slaves, but on the thinner soils of the hills it was not found economical to utilize slave labor. After the emancipation of the negroes most of them remained in the limestone areas. In Warren County, therefore, the character of the soil has not only determined the crops grown, but has to a large extent influenced the social life and political affiliations of the inhabitants.

CLIMATE.

The appended table, compiled from the records of the Weather Bureau, shows the normal monthly and annual temperature and precipitation for Bowling Green, near the center of Warren County, and Franklin, 5 miles south of the Warren County line. The figures for the two points differ but little, and may be taken to represent conditions throughout the area. It will be seen that the county has a temperate climate with abundant rainfall for the year, though droughts may occur during the months of September and October.

Normal monthly and annual temperature and precipitation.

Month.	Bowling Green.		Franklin.		Month.	Bowling Green.		Franklin.	
	Temperature.	Precipitation.	Temperature.	Precipitation.		Temperature.	Precipitation.	Temperature.	Precipitation.
	°F.	*Inches.*	*°F.*	*Inches.*		*°F.*	*Inches.*	*°F.*	*Inches.*
January	36.8	4.68	38.2	3.92	August	79.6	3.61	76.7	3.45
February	37.2	4.35	38.4	4.58	September	71.6	2.91	71.1	3.17
March	47.8	5.34	48.3	5.90	October	58.9	2.02	58.9	1.83
April	58.4	4.19	60.1	4.49	November	46.8	4.19	48.0	4.16
May	67.6	4.27	67.1	4.14	December	37.9	3.99	40.6	4.06
June	76.1	3.77	75.1	3.76	Year	58.2	47.49	58.4	47.46
July	79.4	4.17	77.8	4.00					

PHYSIOGRAPHY AND GEOLOGY.

Warren County occupies part of a great plateau extending over central and southern Kentucky and a large part of Tennessee, and known as the Highland Rim. The approximate range in elevation of this county is from 500 to 750 feet above sea level, the land having a general slope toward the northwest, though some of the highest hills are in the northern part of the county.

The area is drained entirely by the Green River and its tributaries, and the present configuration of the country has been brought about by the comparatively rapid erosion of these streams. Green River forms the northern boundary of the county, flowing westward and finally northward to the Ohio, while Big Barren River, its largest tributary, nearly bisects the county, forming a junction with Green River in the northwest corner. Both streams have a remarkable depth in proportion to their width. Green River is navigable along the whole of its course bordering the county, and Big Barren River as far up as Bowling Green. The banks of both streams are generally high, so that only occasional dams are needed to give an ample depth of water.

Along a large part of the course of these streams rocky hills and cliffs stand up to a height of 150 feet or more above the level of the river, and are a marked feature of the landscape. When such rock outcrops cover sufficient areas to be of importance they have been indicated as Rough stony land.

In places the valleys widen out, and at a height of 10 to 50 feet above the river level are found deposits of alluvial material laid down by the stream in time of flood. Such river bottoms have been mapped as Clarksville loam. Stretching away from the low and comparatively level tracts are the uplands, first gently undulating, then becoming more hilly as the distance from the river increases. The soils which cover this character of topography are silty and clay loams underlain by red clay, and are referred to in this report as the Clarksville clay loam and the Clarksville silt loam. In the northern and western parts of the county these rolling plains terminate in bluffs of limestone capped with sandstone. The summits of these hills are nearly flat. The soil derived from the disintegration of the sandstone is called the Dekalb silt loam.

The limestone, which everywhere underlies Warren County at a greater or less depth, belongs with the St. Louis group of the Subcarboniferous. It consists of a massive limestone varying in color from a creamy white to a dark drab. It is sometimes crystalline, and nearly everywhere highly fossiliferous. There are strata of some thickness having an oolitic structure. The limestone weathers rapidly to a red or gray soil, depending on the relative amounts of siliceous material that enter into its composition. The concretionary stone in some places produces a heavy brown clay, but such strata are not usually of sufficient thickness to influence any large extent of the surface soil.

Sink holes, characteristic of nearly all limestone countries, are abundant in Warren County and have had a marked effect upon the landscape, as they form many of the inequalities of the surface of the limestone areas. These sinks are rounded depressions, which owe their origin to the dissolution and removal of the limestone by percolating waters, and the subsequent sinking of the overlying material into the cavity produced. This process usually goes on so gradually that the sinks assume their rounded contours at the time of their formation. They vary in diameter from a few feet to more than 300 feet. Water is often found in the bottoms of these sinks, and in some places the ponds do not fail during the longest droughts. A number of caverns lead away from the sinks, but very few have been explored.

The sandstone from which the Dekalb silt loam is derived is of the Chester group of the Subcarboniferous. It is a fine-grained sandstone, and often has a shaly structure. In color it ranges from gray to light brown.

Above the sandstone occurs the representative of the conglomerate which is so widely distributed under the Coal Measures. It has a thickness of only a few feet in this locality, and does not influence the texture of the surface soil.

The Coal Measures have a slight exposure in several small areas, and coal mines have been worked on a small scale in the northern part of the county. Aside from the fact that the shale and stone fragments are more abundant in the vicinity of these outcrops, there is no marked difference in the soils.

The mineral resources of Warren County, though not great, exert some influence on the prosperity of the agricultural classes. The chief mineral products are building stone, coal, and asphalt. The St. Louis limestone develops in places the qualities of an excellent building stone, and the material may be secured ready for use at a cost but little greater than that of brick. The tougher parts of the stone may be used for paving. Very ornamental and substantial fences may be constructed of the rough stone at a reasonable cost. The most important use to which the limestone has been put is in the construction of good roads. The 150 miles of excellent pike in the county are due to the cheapness with which macadamized roads can be constructed of the rock available at the roadside. Even where the stone is simply broken and scattered over the road it packs and wears into a fairly smooth and compact roadbed.

SOILS.

The soils of Warren County have been classified into five distinct types. The following table shows the actual and relative extent of each type:

Areas of different soils.

Soil.	Acres.	Per cent.
Clarksville silt loam	232,832	68.0
Dekalb silt loam	89,408	26.3
Clarksville clay loam	9,408	2.8
Clarksville loam	7,552	2.2
Rough stony land	2,176	.7
Total	341,376	

CLARKSVILLE SILT LOAM.

The Clarksville silt loam, by reason of its large area and its agricultural value, is the most important soil type of Warren County. It comprises 232,832 acres, or 68 per cent of the total area of the county.

The soil, to an average depth of 10 inches, consists of a whitish-gray silty loam. When wet it is loamy, and if plowed when too wet it clods slightly, but after drying the clods are easily broken down into a floury white powder. The subsoil is a red clay loam containing a large percentage of silt and having a compact structure. Immediately beneath the soil it is yellowish red, but the color quickly grades into red. At about 3 feet the color usually becomes a deeper red, and the texture has a waxy character. Occasional chert nodules or masses of quartz that have resisted weathering are found in the subsoil and in places strewn over the surface, but there is no uniformity in the occurrence or in the amount of these materials. The top soil is, as a rule, thinner near Big Barren River about Bowling Green, where it grades in places into the Clarksville clay loam. In the more hilly portions the soil becomes deeper, and over small areas may attain a depth of 18 inches or more.

The Clarksville silt loam occupies an extensive area in the southern and southeastern parts of the county. In the southern part the soil is more uniform and the area is almost unbroken, but as one proceeds northward the area is broken by stream valleys, and by hills capped with sandstone, which give rise to other soil types. The soil is everywhere marked by more or less stone, but the outcrops and stone fragments are more plentiful in the valleys where the limestone under the sandstone has been exposed by erosion.

The topography of this type varies from the gently undulating country near the center of the county to the more rolling hills in the northern part of the county. The hills usually have a gentle slope that permits cultivation to the summits. The sink holes are numerous in this type of soil, and to them is due much of the inequality in the surface.

The Clarksville silt loam is of purely residual origin, having been derived from the St. Louis limestone by a process of weathering in which the carbonated waters have dissolved and carried away the calcium carbonate of the limestone and left behind the siliceous and other less soluble constituents. Where this process has gone on undisturbed the proportion of insoluble material present in the original rock has determined the present depth of the top soil. The thin belt of highly crystalline limestone has left a heavy soil with little sandy or silty top soil, but such areas are of limited extent and unimportant from an agricultural standpoint.

This type of soil has been in general cultivation for about one hundred years, and much of it is now spoken of as worn-out and exhausted. The present productiveness depends on the character of the cultivation to which it has been subjected and to the care which has been taken to maintain the crop-producing power of the land. In recent years more attention has been paid to the restorative systems of farming, and many of the old farms that a few years ago were considered worthless have regained their former value. The Clarksville silt loam is naturally a strong soil, and should stand an almost indefinite period of the proper kind of farming without any deterioration. Crop rotations are practiced to some extent, but usually in a haphazard manner. The farmers should adopt some systematic rotation that by experiment has proved to be best suited to this type of soil.

Tobacco is the money crop on this soil. The yield is on an average about 800 pounds per acre, though good crops may run to 1,200 pounds or more per acre. A good yield of corn is from 30 to 40 bushels per acre. Wheat and oats are grown to some extent. The yield of wheat is about 25 bushels for average years. Timothy and clover are grown to some extent for hay. This soil is not adapted to bluegrass, but there are valuable native grasses to furnish pasture for the horses and cattle raised on nearly every farm.

The following table gives the results of mechanical analyses of the fine earth of typical samples of the Clarksville silt loam:

Mechanical analyses of Clarksville silt loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11660	1 mile E. of Green Hill.	Loose silt, 0 to 8 inches	0.1	1.0	0.4	2.4	5.9	78.1	12.1
12190	1 mile S. of Bristow	Gray silty loam, 0 to 10 inches.	.3	1.4	1.5	4.5	3,8	67.6	20.6
11661	Subsoil of 11660	Silty clay, 8 to 36 inches	.4	.5	.1	1.6	3.9	68.2	25.2
12191	Subsoil of 12190	Red silty clay, 10 to 36 inches.	.4	1.4	.7	5.5	2.0	59.5	30.0

CLARKSVILLE CLAY LOAM.

The Clarksville clay loam consists of a heavy red silty loam, with an average depth of 8 inches, underlain by a heavy red clay. The soil contains almost as much silt as the soil of the Clarksville silt loam, but the percentage of clay is greater and the percentage of sand is less. This proportion gives a soil of more plasticity, which forms into clods more readily when plowed wet. The subsoil is tenacious and even waxy in places. It becomes heavier with depth to 3 feet, where the finest texture is attained, and no further increase in heaviness takes place before the unweathered rock is reached. The influence of this heavy subsoil is the principal reason for classing this soil with the clay loams, instead of with the silt loams.

The largest areas in which this type of soil is well developed are an area lying south of Bowling Green and including a part of the town, and a long, irregular strip beginning about 3 miles northeast of Bowling Green. There are a number of small patches of the type scattered throughout the Clarksville silt loam areas, but they are not representative of the type, being due to the rapid erosion of hillsides and the partial weathering of the exposed clay.

The typical development of this soil occurs on the more level portion of the ridges of the Big Barren Valley, formerly known as the "Barrens," on account of the lack of timber growth when first discovered by the pioneers. In some areas south of Warren County difficulty is experienced in securing proper drainage for this type of soil, but here the country is sufficiently rolling to insure adequate drainage in the rainy seasons.

The Clarksville clay loam has the same origin as the Clarksville silt loam—namely, it has been derived from the weathering of the St. Louis limestone. The difference in texture of the two soils may be due to a difference in the amounts of siliceous material in the original rock.

This is considered the best soil of the area for general farming. The principal crops are wheat, clover and the grasses, and corn. The heavy soil is especially adapted to the production of wheat and clover, but tobacco does not attain so fine a quality as on the Clarksville silt loam. Some of the finest farms of the county are to be seen on the Clarksville clay loam, which, on account of its adaptation to grass, is highly esteemed for cattle raising.

The following table gives the result of mechanical analyses of typical samples of the Clarksville clay loam:

Mechanical analyses of Clarksville clay loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12186	¼ mile W. of Bristow.	Red silty loam, 0 to 8 inches.	0.1	0.6	0.6	2.0	1.0	74.8	20.7
12188	1 mile NE. of Bristow.	Red heavy silt loam, 0 to 8 inches.	.3	1.2	1.2	7.9	2.7	62.9	23.4
12187	Subsoil of 12186	Red heavy clay, 8 to 36 inches.	.6	1.2	.8	3.3	1.2	53.4	39.4
12189	Subsoil of 12188	Red heavy clay, 8 to 36 inches.	.5	1.0	.9	7.2	2.3	45.8	41.7

CLARKSVILLE LOAM.

The Clarksville loam is the only sedimentary type of the area. The soil, to an average depth of 18 inches, is a dark-brown silty clay, containing more than 65 per cent of silt and nearly 30 per cent of clay. Although the proportion of sands of all grades is very small.

the soil is granular and friable, which gives it some of the characteristics of a fine sandy loam. The subsoil, in places extending to a depth of 30 feet or more, is lighter in color than the soil, but there is no difference in texture between soil and subsoil. The areas of this type of soil are remarkably uniform, the only variations occurring where sand bars have been deposited near the streams.

The larger areas of the Clarksville loam are found as narrow strips in the bends of Green and Big Barren rivers, but all the smaller streams have more or less extensive alluvial deposits, and on Drake and Gasper creeks the bottom lands are of sufficient size to be shown in the map. The width of the areas varies greatly. In some places the hills rise abruptly from the water's edge; in other places the bottoms widen out to one-half mile or more.

The areas of Clarksville loam have an elevation of from 10 to 50 feet above the level of the rivers. They are terracelike and gently undulating, and there are no areas of perfectly level land more than a few acres in extent. The bottoms merge so gradually into the upland areas that it is difficult in places to define the exact boundaries of the alluvial deposit. The drainage is usually adequate in seasons of ordinary rainfall. In times of flood the lower bottoms are subject to overflow, and about once in five years the overflows result in damage to the crops over perhaps one-third of the bottom lands.

The Clarksville loam is plainly an alluvial deposit laid down during these floods. The deposits along the Big Barren River must have been derived largely from the limestone soils, and those along Green River from the sandstone, but there is no difference in texture to indicate this. This is due, perhaps, to the fact that all the materials in suspension in the flood waters were fine and there was no assorting of the different soil grains by currents of varying velocity. As a general rule, the soils along Big Barren River are more productive than those along Green River.

The Clarksville loam is considered the most desirable land in the county for the production of corn and grasses. The average yield of corn is from 25 to 40 bushels per acre, but 65 bushels per acre are secured on the better portions of this soil. Grasses are grown both for pasture and hay. Wheat is not grown to any great extent on the bottom lands. The quality of the tobacco grown on this type of soil is not good, and very little is produced. The Clarksville loam is so valuable for farming purposes that practically none of it is now in forest.

The following table shows the results of mechanical analyses of the soil and subsoil of the Clarksville loam:

Mechanical analyses of Clarksville loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12178	2 miles N. of Bowling Green.	Brown silty clay, 0 to 18 inches.	0.0	0.0	0.2	3.3	4.3	64.5	27.3
12180	1 mile N. of Riverside.	Brown silty clay, 0 to 20 inches.	.0	.0	Tr.	.5	2.3	67.6	29.4
12182	2 miles NW. of Riverside.	Brown silty clay, 0 to 18 inches.	.0	.2	.1	.4	.8	67.4	30.5
12183	Subsoil of 12182	Brown silty clay, 18 to 36 inches.	.0	.0	.1	.2	.6	68.9	29.8
12179	Subsoil of 12178	Brown silty clay, 18 to 36 inches.	.0	.2	.3	1.5	2.3	64.2	30.9
12181	Subsoil of 12180	Brown silty clay, 20 to 36 inches.	.0	Tr.	.2	.7	1.4	61.4	35.8

DEKALB SILT LOAM.

The soil of the Dekalb silt loam, to a depth of 14 inches, is a whitish-gray silty loam. The silt content ranges from 55 to 75 per cent, and there is usually from 10 to 20 per cent of fine and very fine sand, and about the same proportion of clay. The subsoil is a silty loam carrying a larger percentage of clay than the top soil. This material may range in depth from a few feet to 20 feet, or until the bed-rock sandstone is encountered. In color the subsoil is a yellow or light brown, passing in places into a light red.

The Dekalb silt loam occupies a large, irregular area in the northern and western parts of Warren County, and several smaller areas at the summits of hills and ridges where it has not been removed by erosion.

The type is derived from the Chester sandstone, which immediately overlies the St. Louis limestone. It occurs as a cap of varying thickness over the plateaulike hills that rise above the more level limestone areas, and as a thin covering over a number of hills that rise above the general level in the northern part of the limestone outcrop.

Around the borders of the Dekalb silt loam areas the land is rough and stony, due to the rapid erosion of the limestone under the sandstone. When the top of the table-land is reached, however, the land is more level, and while erosion has gone on extensively near the streams, there are considerable areas of level land. Drainage is everywhere good on this type of soil, and owing to this fact and to the pervious nature of the soil, crops are likely to suffer from drought. It is very seldom that crops on this soil escape completely from the injurious effects of dry weather.

The crops which thrive best on the Dekalb silt loam are corn, tobacco, and oats. Corn yields well when there is sufficient rainfall, but this occurs only about once in three years. The tobacco produced has a slightly better reputation in the local markets than that grown on the heavier soils of the county. The yield is from 600 to 1,000 pounds per acre, with an average from year to year of about 750 pounds per acre. The few apple orchards on this soil produce fruit of good appearance and splendid keeping qualities. It should be profitable to grow applies on a commercial scale, though at present they are grown only for home use and to supply a small local demand.

The Dekalb silt loam is undoubtedly a strong soil, and with favorable climatic conditions should be very productive, but with the amount of rainfall in this region the greatest care must be exercised to counteract as far as possible the effects of drought. The whole system of farming should be directed to conserving the moisture supply of the soil so as to sustain the crop during the short droughts that are likely to occur through the growing season.

The following table gives the results of mechanical analyses of the fine-earth portion of the soil and subsoil of this type:

Mechanical analyses of Dekalb silt loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11662	1 mile N. of Sandhill.	White silty loam, 0 to 10 inches.	0.3	1.5	0.6	4.6	8.9	72.1	11.7
12198	1 mile N. of Richardsville.	Gray silty loam, 0 to 16 inches.	.8	1.5	.6	9.9	9.5	55.9	21.5
11663	Subsoil of 11662	Yellow silty loam, 10 to 36 inches.	.2	.7	.7	6.4	13.2	61.1	17.2
12199	Subsoil of 12198	Yellow silty loam, 16 to 36 inches.	1.5	2.2	.8	9.3	7.6	53.5	25.0

ROUGH STONY LAND.

The term "Rough stony land" has been applied to narrow strips of hillside which are so covered by loose stones as to be unfit for cultivation. Such areas occur along the larger streams where the current has cut rapidly back into the hillside, or along the contact between the St. Louis and the Chester formations. In both cases the surface exposures are of the St. Louis limestone.

The thin soil is usually a gray silty loam, underlain by a red clay loam, and is similar to the Clarksville silt loam. Very little of the stony land is under cultivation, owing to the difficulties of tillage. The extensive area uncultivated is not entirely worthless, since the greater part makes a fair pasture when cleared, and where it is allowed to grow up a valuable growth of cedar covers the hills to their summits.

AGRICULTURAL CONDITIONS.

The chief interests of Warren County have from the time of the earliest settlements been centered in agriculture, and uniform success has attended the enterprise of the farmers.

The dwellings are, as a rule, well-constructed frame buildings. Some old mansions are seen in the county, as is usually the case where the long tenure of land prevails. Farms change hands less frequently than in the more recently settled communities, and land is seldom bought by persons living in other counties and States, though the county has many advantages in the way of climate and cheap farming lands. The farm buildings are ample for the needs of the agriculture practiced. Large barns are not needed where the climate is not severe enough to necessitate the housing of cattle during the winter. Large tobacco barns are also unnecessary, as no artificial heat is required in the curing of the type of tobacco produced in this part of Kentucky.

The farms are well fenced with barbed or woven wire. The posts used are of the red cedar, which grows so plentifully in the limestone areas. Stone fences built of the square blocks of limestone are sometimes seen, and add much to the appearance of the farm. The cheapness with which these fences can be built should make them more common, especially about the dwellings and barns.

The machinery used in the farm operations is up-to-date and the best that can be applied to this character of country. Mowing machines and binders are seen on nearly every farm, and corn harvesters and shredders are being introduced.

The system of general farming and cattle raising practiced in Warren County makes it necessary that the owner of the soil should live on it, so that the tenant system does not prevail here as in some parts of the South. About three-fourths of the farmers own the land they cultivate, and less than 20 per cent are share tenants. Incumbrances in the form of debts and mortgages are very light. The price of land ranges from $3 to $50 an acre. The rocky land is almost worthless, except for the timber, while the most valuable land is found in the level areas of clay loam near Bowling Green. The average value for all land, exclusive of buildings and other fixed improvements, is about $13 an acre.

There has not been a rapid subdivision of farms as a result of an influx of new settlers, but in some parts of the county there has been a gradual breaking up of the large estates. By the census of 1900 the average size of farms in Warren County was 98.6 acres, a decrease from the average of 116 acres in 1890. The number of farms containing from 100 to 500 acres had remained about constant during the decade, but the larger holdings had been subdivided. This subdivision can go on for some time yet before there will arise any scarcity of land. It has long been the custom, however, for the surplus farming population to go west or south, where land is cheap and abundant, rather than attempt to farm on smaller places.

Both white and colored laborers may be secured for work on the farms. The colored population is confined to the southern and central portions of the county. While very few laborers are hired by the year, or even by the month, there are times, as in the planting and harvesting seasons, when the farmer must have help, so that the aggregate labor bill is no small item, amounting to more than $100,000 per annum for the county. The laborers are of sufficient intelligence and skill to perform the class of work required. Labor is naturally becoming scarcer and higher in price as the manufacturing interests of the community are developed. There is a growing tendency, especially among the colored laborers, to flock into the towns, where higher wages and more congenial surroundings may be found.

The most important products of the soil are corn, tobacco, hay, and wheat, ranking in value in the order named. Of these only corn and tobacco leave the farms in the raw form. The 70,000 bushels of wheat grown are not sufficient to supply the needs of the county. All of the hay and nearly all of the corn is fed to live stock and sold in the form of hogs, beef cattle, and horses. The hay and forage crops are of much importance. Clover is the chief leguminous crop grown for hay, and the total yield is about 2,500 tons, or an average of nearly 1 ton to the acre planted. Other tame and cultivated grasses bring the hay product of the county to a total of about 6,200 tons. The greater part of the grass lands, however, is devoted to pasture. Sorghum is being more widely grown every year as feed. Some 30,000 gallons of sorghum sirup are also made in the county each year.

Warren County is outside of the export tobacco belt, and the tobacco grown is for domestic consumption. All of the product is air cured in the simplest manner. The leaves are cut, strung on horizontal bars, and suspended in ventilated sheds to allow free circulation of the air. By this process the natural aroma of the leaf is preserved and no foreign flavors are added. The entire crop, which ranges from 1,500,000 to 2,000,000 pounds annually, is sold to the local dealers and manufacturers of Bowling Green. The tobacco bought by the dealers, amounting to about three-fourths of the crop, is shipped to Louisville, where it is manufactured into smoking and chewing tobacco. There are three local manufacturing establishments, which use the remainder of the crop. Two of them make twist and smoking tobacco of excellent reputation, while the third makes a cheap grade of cigars.

Notwithstanding the simple manner in which the tobacco is grown and cured, it has not proved a remunerative crop, and the acreage is decreasing each year. There are now few farmers that put out more than 4 or 5 acres each. The price obtained for this kind of tobacco ranges from 2½ to 6 cents a pound, and the average price is about 5 cents. When buying from the farmer the dealer does not grade the tobacco, but the market price is paid for the whole. Exceptions are made in the case of very fine lots, which may bring a fancy price.

There is so little specialization in the farming of this area that the adaptation of soils to crops has not been a subject of careful study on the part of the farmer. Corn and wheat are grown to a greater or less extent on every soil type. Tobacco is a crop usually quite dependent on the texture of the soil, but here it is not confined to any certain type of soil. Local variations of topography and accumulations of organic matter are considered of more importance than general textural differences. The newly cleared beech lands are supposed to produce a sweeter tobacco than the lands that have been under cultivation for a long period. This advantage, however, is only maintained for two or three years, and as the original "beech land" is so limited in extent, the amount of this tobacco is small, and it brings no more in the market than the bulk of the crop. There is some difference in the yield of tobacco on the several types of soil. The Clarksville silt loam and the Clarksville clay loam produce more heavily than the lighter Dekalb silt loam. From 700 to 1,000 pounds per acre is considered a good yield on the heavier soils, and as much as 1,200 pounds has been produced on the heavier soils where special attention was given the crop, while the yield on the lighter soils about Richardsville seldom exceeds 600 pounds per acre. The average yield for the county on all types of soil is about 800 pounds per acre.

Railroad transportation is furnished by the Louisville and Nashville Railroad. Bowling Green is on the main line, which runs from

Louisville southward, while the Memphis branch leaves the main line near the center of the county. The shipping by river is of considerable importance. Boats and scows of good size can be brought up to Bowling Green, and much of the timber, asphalt, and coal shipped to or from Bowling Green is carried by water.

The county is abundantly provided with good roads. More than 150 miles of pike have been improved with rock, making a road system that has few equals in the country. On account of the cheap and easily procured stone the cost of constructing these roads has been comparatively low. The main roads leading out from Bowling Green have been well graded and macadamized, and the less traveled roads have been treated in the worst places, so that a piece of really bad road is hardly to be found in the county.

Bowling Green is the natural market for the farm products of the county, and the good roads enable the farmers to come from all parts of the county to market their produce and make their purchases. Among the industries of Bowling Green are three tobacco manufacturing plants and a cannery. These depend upon the farmers for their raw material. There are also railroad shops, foundries, and machine shops. Bowling Green has long been noted as a market for horses and mules, and there are a number of feed and sale stables to meet the demands of this trade. Large shipments of mules are made to the plantations farther south, and horses, especially saddle horses, are shipped to all parts of the country.

With a productive soil, agreeable climate, and these facilities for marketing his produce, there is no reason why the farmer of Warren County should not enjoy a long period of prosperity.

SOIL SURVEY OF THE WOOSTER AREA, OHIO.

By THOMAS A. CAINE and W. S. LYMAN.

LOCATION AND BOUNDARIES OF THE AREA.

The Wooster area is located in northeastern Ohio and includes a large proportion of Wayne and Stark counties and smaller areas in Medina and Summit counties. It is rectangular in shape, having a width of about 17 miles north and south and a length of about 27

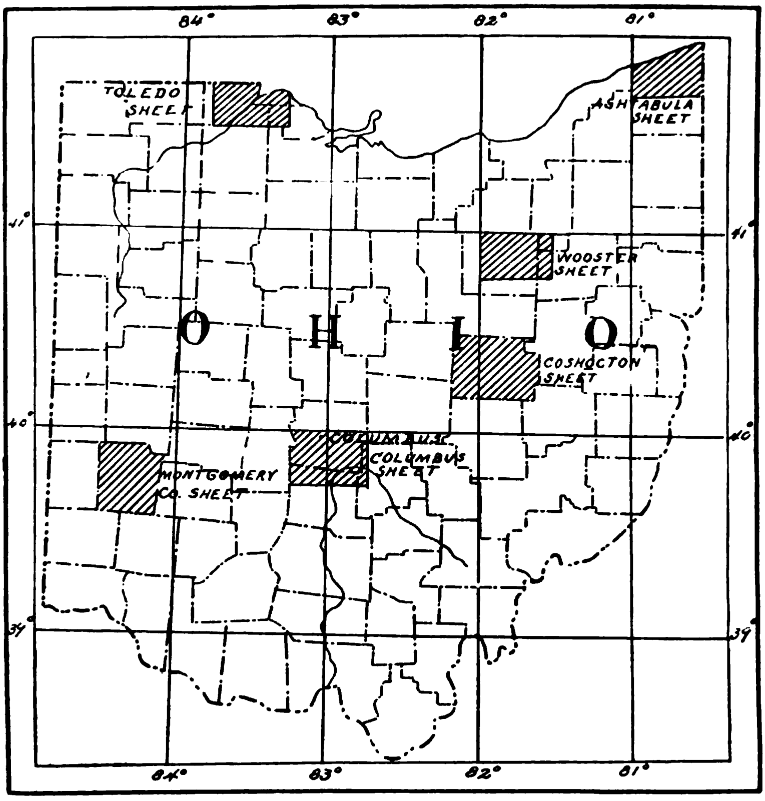

FIG. 22.—Sketch map showing location of the Wooster area, Ohio.

miles east and west. It is included within parallels 40° 45′ and 41° north latitude, and meridians 81° 30′ and 82° longitude west from Greenwich, and therefore has an area of 300,352 acres, or about 469 square miles. The cities of Wooster and Massillon are situated within the area.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Although the first permanent settlement within the present limits of Ohio was made in 1788, it was not until 1805 that any settlements took place within the limits of the area surveyed. Between 1807 and 1810 several settlements were made in the vicinity of Wooster. In 1808 the town of Wooster was laid out, and two years later the first State road in the area, extending from Canton to Wooster, was built.

The first settlers made their way into the region from their eastern homes in wagons, and some even came on foot. They usually took up lands along the larger streams, or "second bottoms," where water for domestic purposes was abundant and where power for the operation of mills was obtainable. There was no incentive in those days to cultivate the soil except to supply the family needs, to support the stock, and to pay the taxes. The forests and streams furnished an abundance of game and fish. There were no local markets and little exchange of products with the older settlements, because of distance and cost of transportation. The nearest markets were Pittsburg and Cleveland. The prices of the staple products, such as wheat, corn, and potatoes, were extremely low. Wheat sold in Wooster as low as 25 cents a bushel.

The first impetus to agriculture occurred during the era of canal construction. With the completion of the Erie Canal from Albany to Buffalo in 1825 and the construction of the Ohio Canal in 1828, which connected the area with Cleveland, immigration increased and agriculture began to develop along all lines. In the decade that followed there was a great influx of Germans from Pennsylvania, and later of German immigrants, so that at present about 70 per cent of the population of the area is of this race. With the improvement in transportation and the increase of settlers the uplands were gradually cleared and prepared for cultivation, as well as the lands along the streams. Grain was the chief product, and large quantities of it were hauled from all parts of the area to Fulton and Clinton and shipped to Cleveland, Buffalo, and New York.

The agricultural development of the area has kept pace with the opening up of means of communication with other parts of the country. The first railroad to penetrate the area was the Pittsburg, Fort Wayne and Chicago, which in 1852 connected Wooster and Massillon with the East. During the era of railroad construction that followed all lines of industry were stimulated even more than in the period following canal construction. Better methods of farming were introduced and larger areas were put under cultivation. The mining industry in the eastern part of the area was soon brought into prominence and manufacturing was established. There have been, however, several periods of depression, notably after the construction of transcontinental railroads, when the area came into competition with the new West, where there were vast tracts of prairie lands, upon which grazing and grain growing could be carried on more cheaply than upon the small eastern farms. The products of these new lands were put upon the eastern markets more cheaply even than they could be produced in this area. By a judicious system of diversified farming the industrious German farmers of the area have adjusted themselves to these new conditions. As an adjunct to general farming many of them are engaged in feeding horses. Two and three year old draft and coach horses are sent from Indiana and Illinois by the carload and let out by local dealers to the farmers to be fed until they are 5 years old. Many carloads of these horses are shipped to the eastern markets annually.

CLIMATE.

At Wooster the hottest months are July and August, when the temperature seldom gets above 100° F. for more than one day, and the normal for these two months, computed from records covering fifteen years, is about 70° F. The coldest month is February, during which the mercury seldom falls below zero, and the normal is 26.8° F. The normal annual temperature at Wooster is 49.2° F., while that for the whole State for the same period is 51.1° F.

At Wooster the greatest precipitation takes place during May, June, and July, when the growing crops are most in need of rain. The normal for these months is a little over 4 inches per month. April is the month in which the least precipitation occurs, the normal being 2.39 inches. The normal annual rainfall at Wooster is about 38.5 inches, while that for the whole State for the same period is about 37 inches.

There is usually plenty of rainfall for the heavier soils, but sometimes such types as the Miami gravelly loam, Miami sandy loam, and Miami sand suffer from drought during the month of August. In the winter there is usually enough snow to protect the wheat. All crops are about two weeks later in the area than in the southern part of the State.

The following table shows the normal monthly and annual temperature and precipitation for the Weather Bureau stations at Wooster, Killbuck, and Medina:

Normal monthly and annual temperature and precipitation.

Month.	Wooster.		Killbuck.		Medina.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	° *F.*	*In.*	° *F.*	*In.*	° *F.*	*In.*
January	25.9	2.74	27.8	2.48	25.6	2.74
February	27.8	3.42	26.4	2.55	25.8	2.10
March	35.2	3.28	38.7	3.29	36.5	3.56
April	47.9	2.38	50.8	3.77	49.2	2.56
May	57.8	4.26	60.8	3.63	60.1	3.53
June	68.3	4.04	70.8	2.92	68.3	2.49
July	71.1	3.93	73.4	4.68	72.6	4.23
August	67.0	2.44	71.8	2.70	70.6	3.45
September	62.9	3.05	64.6	2.94	65.5	2.56
October	50.3	2.35	50.7	1.78	51.9	2.08
November	39.6	3.23	39.6	3.23	41.4	3.48
December	32.2	2.77	31.2	....	30.6	3.04
Year	48.8	37.89	50.5	....	49.8	35.80

PHYSIOGRAPHY AND GEOLOGY.

The area is located along the southern crest of the divide between the Lake Erie and Ohio River drainage, with nearly all of the streams flowing in the latter direction. The region is made up mostly of gently rolling uplands and wide shallow valleys, but in the coal region in the vicinity of Massillon, Dalton, and Doylestown it is rather hilly and broken and farmed with less ease than in the western part of the area.

The uplands are cut by two deep preglacial drainage channels, one at Wooster and the other at Massillon. As shown by well borings, these channels were originally much deeper than at present, but were partially filled with drift material during the Glacial period. The difference in elevation between the streams that flow in these valleys and the tops of the hills varies from 100 to 200 feet. There are no gorges or rock exposures, however, as the sides of the valleys are covered with glacial till and in most cases permit of cultivation to the top. The lowest point in the area is 925 feet above sea level, while the highest point is 1,275 feet, so that throughout the area there is a difference in elevation of only 350 feet.

The soils upon the valley floor are alluvial in origin, having been deposited either by torrents at the close of the Glacial period or by the spring freshets since that period.

In the lowest parts of the valleys and along the flat divides, where the drainage conditions were naturally poor, sedge grasses, mosses, and similar vegetation flourished, and the accumulations year after year account for the deep deposits of Peat at Creston, Orrville, and Lodi.

The soil-forming glacial till found at present upon the uplands represents approximately the character of the material left at the close of the Glacial period. A great deal of the material is local, being derived from the underlying rock formations.

The investigations of the State geologists of Ohio, as recorded in the reports and maps, show that the underlying rocks of the area belong to the Carboniferous period. The rocks of this period are subdivided into various formations, the Black Hand, Logan, Maxville, and Pottsville formations being the ones represented in the area.

Each of these underlying formations has its own characteristic rock, which, when it comes close to the surface, often imparts that characteristic to the soil; but when deeply covered with glacial till its influence is not so noticeable.

In the southwestern part of the area, in the vicinity of Wooster, the rocks of the Black Hand and Logan formations come rather close to the surface and enter largely into the formations of the overlying soil. Farther to the northward, however, in the vicinity of Golden Corners, these formations thin out and are displaced by an argillaceous shale, which has imparted to the soil a more clayey nature than at Wooster.

After passing eastward above the Black Hand and Logan formations the Maxville limestone appears rather close to the surface in places, especially upon the hills above North Lawrence. The soil is quite heavy in that locality. The limestone is burned by some of the farmers, and lime is said to be very beneficial to the soil.

Passing eastward above the Maxville limestone there is found for some distance the Pottsville formation, the rocks of which are largely sandstone. Although this formation is usually deeply covered with glacial till, the underlying sandstone has been somewhat mixed with this till and has had its influence upon the soil. The sandstone of this formation is quarried at Massillon and is widely known and extensively used for structural purposes, for grindstones, and in the manufacture of glass. Besides its quarries, the Pottsville formation is also important for its coal beds. In the eastern part of the area the coal interests are extensive, and there are at present many active mines. In the same formation, and sometimes associated with the coal, are beds of clay which are worked for pottery and brick purposes.

SOILS.

There are nine distinct types of soil in the Wooster area, five of which belong to the Miami series.

The following table gives the extent of the several types and the proportion of the whole which each forms:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Miami clay loam	119,104	40.0	Miami gravelly loam	4,928	1.6
Volusia silt loam	79,424	26.5	Miami sand	2,496	.8
Miami stony loam	51,200	16.9	Yazoo clay	1,216	.4
Waverly clay	24,256	8.1	Total	299,712	
Miami sandy loam	11,328	3.8			
Peat	5,760	1.9			

MIAMI CLAY LOAM.

The soil of the Miami clay loam consists of a brown loam or clay loam which contains a high percentage of silt. It varies from 9 to 12 inches in depth, with an average of about 10 inches. The line of demarcation between soil and subsoil is quite distinct as to color and texture. The subsoil to a depth of 20 inches is a light-brown or yellowish clay loam, below which the clay content increases considerably, the texture changing to a clay and the color to a mottled drab and yellow. It is comparatively free from the gravel and rock fragments which are characteristic of the Volusia silt loam and which aid materially in the underdrainage of the latter type. Glacial bowlders, however, are usually present in considerable numbers, and in places they were formerly so plentiful as to interfere with cultivation.

The type is found in the northern and eastern parts of Wayne County and in western Stark County. Large bodies of it are also found in Medina County, outside of the area. Within the area it is typically developed in the region between Golden Corners, Burbank, and Jackson, in Wayne County, and in the region between Dalton, East Greenville, and North Lawrence, in the southeastern part of the area.

The desirability of Miami clay loam for general farming depends considerably upon whether it is located in a comparatively level region, where the drainage conditions are naturally poor, or whether it is more rolling and consequently better drained. The first condition is found in the vicinity of Golden Corners, 9 miles north of Wooster, where it occupies a comparatively level region, characterized by beech woods, locally known as "Büchenwald." Here a smaller proportion of the type is under cultivation, and the farmers are less prosperous than where it is found in more rolling or hilly areas bordering streams, as, for example, in the vicinity of North Lawrence and East Greenville. Tile drainage has greatly improved the type by making it more porous and less subject to drought in dry seasons. It has also made it a warmer soil, which may be plowed earlier in the spring than formerly. It is rather a difficult soil to till, owing to its clay content, but when brought to a high state of productivity it is easily maintained because the fertilizing ingredients are more lasting than is the case with types having a porous subsoil.

The Miami clay loam is glacial in origin, being a mixture of the heterogeneous ground-up rock fragments transported from the north in the Glacial time, and more or less intimately mixed with the ground-up fragments of local rocks.

The Miami clay loam is important in point of areal extent, and when naturally or artificially well drained it may be used for any of the general farm crops of the region. In the early days it was covered with forests, consisting of beech, maple, hickory, and oak. It was not cleared and put under cultivation until about fifty years ago. It is not naturally a very productive soil, but it responds readily to careful handling and retains fertilizers very well. It is well adapted to hay, and also, if thoroughly drained, to wheat. All spring-sown crops, including potatoes, give satisfactory results. Apples, grapes, strawberries, and raspberries do remarkably well when properly cared for, but peaches do not thrive. A smaller proportion of this soil is under cultivation than is the case with the Volusia silt loam, and the general appearance of farm buildings, fences, and orchards does not indicate the same degree of prosperity as is attained upon the latter type.

Grass, wheat, corn, oats, potatoes, and fruits are the principal products grown. Wheat will average about 15 bushels per acre, corn about 40 bushels, when well cultivated, and oats about 50 bushels in ordinary seasons. This type generally shows an acid reaction when tested with litmus paper, and the application of lime would doubtless prove beneficial.

The following table gives the results of mechanical analyses of the fine earth of typical samples of this soil:

Mechanical analyses of Miami clay loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10752	3 miles N. of Madisonburg.	Brown silty loam, 0 to 10 inches.	0.6	1.9	1.3	3.5	10.0	63.4	19.4
10926	2¼ miles E. of Marshallville.	Brown clay loam, 0 to 9 inches.	1.1	1.6	1.3	3.8	6.1	57.7	27.5
10753	Subsoil of 10752	Yellow clay loam, 10 to 36 inches.	1.6	1.9	1.0	3.6	12.8	50.1	28.9
10927	Subsoil of 10926	Yellow clay, 9 to 32 inches	.4	1.1	1.0	3.2	5.2	43.5	45.0

MIAMI STONY LOAM.

The soil of the Miami stony loam is a brown silty loam, with an average depth of about 12 inches, and grading gradually into a subsoil of yellowish and sometimes reddish loam or clay loam. At a depth of from 4 to 10 feet it is often underlain by gravel, sand, and bowlders, which, as seen in road cuts and in gravel and sand banks, exhibits little evidence of stratification.

In texture this type is intermediate between the Miami clay loam and the Miami sandy loam, but there are important characteristics which separate it from either of these types. The subsoil appears considerably more clayey than that of the former and more sandy than that of the latter, and scattered upon the surface and disseminated through both soil and subsoil are numerous well-rounded glacial bowlders, varying usually from 1 to 10 inches in diameter, with occasionally some much larger. Formerly these rocks were so numerous as seriously to interfere with cultivation, and in places the farmers still have trouble, the stones being so numerous that they are plowed up year after year.

The Miami stony loam is confined to the northeastern part of the area and is found typically developed on the uplands in the vicinity of a group of lakes south of Akron. It is characterized by an uneven topography, consisting of many hills and ridges with kettle-hole depressions between. Occasionally there are broad, gently rolling uplands, and when such is the case the subsoil contains a little more clay, and the type is more desirable for general farming than on the sidehills, where the surface often washes badly and is subject to drought in dry seasons. As a whole, the type is naturally well drained, except in the kettle holes, which are usually only a few acres in extent, too small to be shown on a map of the scale used. Some of these are filled with water throughout the year, while others dry up during the summer. In some cases these areas have been successfully drained, but in many others the expense of digging an outlet would make drainage unprofitable. The character of the material found in the depressions is the same as that found in the larger poorly drained areas, viz, peat, marl, or sand or clay deposits washed from the adjoining hills.

The Miami stony loam is derived from the weathering of glacial till, which is usually of great thickness. Occasionally, however, along the borders of the preglacial valleys or where the till has been removed by erosion the underlying rocks appear and enter somewhat into the formation of the soil. Notwithstanding its rough, hilly topography the Miami stony loam is a fairly satisfactory type for general farming. When not too hilly it is more easily handled than the Miami clay loam, because its clay content is not so high. It is a warmer soil than the Miami clay loam and better adapted to peaches, corn, and potatoes. It is not naturally a very productive soil, but areas where the surface is not too steep are capable of being brought to a high state of cultivation, and the productivity is easily maintained. Timothy and clover do well, and dairying would doubtless be a profitable industry. Its varied topography also makes it a desirable type for fruit and berries. Wheat yields from 15 to 30 bushels per acre, depending upon the season, location, and care taken; corn averages about 40 bushels, oats from 30 to 60 bushels, and potatoes from 75 to 150 bushels per acre.

The following table gives the results of mechanical analyses of the fine earth of samples of this soil:

Mechanical analyses of Miami stony loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10948	2 miles NE. of Clinton.	Brown silty loam, 0 to 10 inches.	1.3	2.2	3.2	7.4	10.3	58.4	17.1
10950	1½ miles SW. of Warwick.	Brown silty loam, 0 to 8 inches.	.7	1.8	2.3	4.7	5.6	65.2	19.5
10951	Subsoil of 10950	Yellow silty loam, 8 to 30 inches.	.8	2.1	2.5	5.4	5.1	60.0	23.8
10949	Subsoil of 10948	Clay loam, 10 to 36 inches	.8	2.7	3.4	9.1	8.2	42.3	33.7

MIAMI GRAVELLY LOAM.

The Miami gravelly loam consists of a heavy brown loam, varying in depth from 8 to 15 inches, with an average of about 10 inches. The subsoil is a heavier yellowish and sometimes reddish loam or clay loam to a depth of about 24 inches, below which the gravel content increases somewhat until, at 30 inches, the material becomes a mixture of gravel and coarse sand. As shown by gravel pits and well records, the substratum of the type consists of alternate beds of gravel and sand, sometimes to a great depth. At Sterling, in the Tuscarawas Valley, this deposit of sand and gravel is 400 feet deep.

The soil usually contains considerable coarse, sharp, angular sand and fine gravel, and there are local variations in the type where the soil is very much sandier. Such spots, caused by the near approach of the underlying sand and gravel to the surface, are found upon the crests of knolls, and are usually not more than an acre in extent.

The Miami gravelly loam is locally known as "second bottoms," and is found at elevations varying from 20 to 40 feet above the streams. It is never subject to overflow. The surface varies from almost level to gently rolling. Its topography, in addition to the fact that it is underlain with gravel, gives the soil excellent drainage. In the typical areas of the soil, where the subsoil consists of a heavy loam or clay loam, it retains moisture well, but where least typical, as, for example, on the asylum farm at Massillon, where the subsoil is lighter in texture, it is inclined to be droughty.

The beds of sand and gravel forming the deep subsoil of this type are glacial in origin. The soil itself may be residual, i. e., derived from the weathering of the underlying sand and gravel beds, or it may be largely alluvial, formed by the annual overflow of the streams when their channels stood at higher levels, in much the same manner as the Waverly clay is being formed at present. The type is found closely associated with the Waverly clay, and in some cases the textural characteristics are quite similar, making it rather difficult to fix the boundaries between the two. The Miami gravelly loam, however, is a much more desirable type for general farming in this area than the Waverly clay, owing to the poor drainage of the latter.

The Miami gravelly loam was among the first types to be taken up by the early settlers who, with few exceptions, made their homes along the larger streams. The chief causes influencing their choice were the advantages of near water supply and the ease with which the lowlands could be put under cultivation. The trees which grew in these locations were the alder, mulberry, willow, haw, and wild plum, all of which were comparatively easy to remove. The typical Miami gravelly loam is a fairly safe soil for all general farm crops, in addition to which considerable quantities of tobacco of the Little Dutch cigar filler type have been grown upon it with satisfactory results in the vicinity of Creston and Sterling. If conveniently situated near a market the best areas could also be profitably used for truck crops.

Wheat will yield on this soil from 10 to 35 bushels per acre, depending upon the season and the condition of cultivation. Corn will average about 40 bushels per acre and oats about the same, although much larger yields of both are not uncommon. The tobacco grown, "Little Dutch," gives an average yield of 1,200 pounds, and potatoes sometimes yield as high as 150 bushels per acre.

The following table gives the results of mechanical analyses of the fine earth of this type of soil:

Mechanical analyses of Miami gravelly loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10754	2 miles SE. of Sterling.	Brown loam, 0 to 10 inches	4.8	9.8	6.2	6.8	7.9	50.5	15.5
10944	2 miles SE. of Sterling.	Brown loam, 0 to 8 inches	2.3	5.5	4.2	8.0	8.1	52.8	19.2
10755	Subsoil of 10754	Yellow sandy loam, 10 to 40 inches.	8.1	23.5	15.7	9.1	7.7	22.7	13.8
10945	Subsoil of 10944	Brown clay loam, 8 to 30 inches.	2.0	6.4	4.1	9.8	10.5	39.7	27.2

MIAMI SANDY LOAM.

The Miami sandy loam consists of from 10 to 14 inches of brown to dark-brown sandy loam, underlain by a lighter colored compact sandy loam containing a little more clay than the soil. There are two phases of the type, one found in the valleys and the other in the uplands. In the lowland phase the subsoil is occasionally gravelly at a depth of 36 inches, while in the uplands the subsoil sometimes becomes slightly more clayey in the lower depths. Upon the hills the soil is a little lighter colored than in the valleys.

In the lowlands the Miami sandy loam is found along all the larger streams in the area, either adjacent to the streams or back from the streams upon terraces. In the upland it is well developed in the northeastern part of the area in the hilly region south of Akron. The lowland areas are flat or gently rolling. In the upland the type occupies smoothly rounded hills and terraces adjoining preglacial valleys. The hills are sometimes small and have kettle-hole depressions between them. The soil upon the hills is lighter colored and more sandy than farther down the slope or in the depressions.

Occasionally the lowland areas are flooded in the spring, but, owing to the porous nature of the subsoil, they dry off quickly and there is little delay in plowing or planting. Owing to its hilly topography the upland phase is also a well-drained early soil, the only exceptions being the small kettle-hole depressions, which often contain water until late in the summer. The type as a whole is subject to drought in the latter part of the growing season, and unless the rainfall is considerable crops do not usually do well.

The lowlands of this soil are purely sedimentary in origin, the material having been deposited when the streams were swollen and the currents too swift to permit of the deposition of silt and clay. The upland areas are largely derived from the glacial mantle, which in the northeastern part of the area is composed mainly of sandy material. Some of the hillocks and elongated ridges have the appearance of eskers and kames.

Potatoes, corn, tobacco, wheat, oats, hay, and truck are successfully grown, the type as a whole, however, being best adapted to potatoes, corn, tobacco, and truck. The lowland phase is particularly well adapted to corn, potatoes, and tobacco, the latter crop being grown more extensively on this than on any other soil in the area. In general potatoes yield from 75 to 150 bushels; corn about 50 bushels, and tobacco—the Zimmer Spanish variety—from 800 to 1,400 pounds per acre, the latter figure representing the best yields on the lowland phase of the type. The success of crops depends largely upon the season, and the yields above given are those obtained in favorable seasons. In the uplands during the prolonged droughts that sometimes occur in the growing season grass and small grains suffer serious damage. As a rule the type is too dry for oats, and it is difficult to get a stand of clover because the seedlings burn off after the wheat is cut. In the region north of Sterling tobacco is very successfully grown.

The following table gives the results of mechanical analyses of typical samples of this soil:

Mechanical analyses of Miami sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10756	Sterling	Brown sandy loam, 0 to 12 inches.	3.5	9.4	11.6	29.2	11.7	24.1	10.3
10934	¼ mile S. of Seville.	Dark brown sandy loam, 0 to 8 inches.	.4	2.5	6.7	34.0	20.4	22.4	13.6
10757	Subsoil of 10756	Brown sandy loam, 12 to 40 inches.	4.0	11.0	12.1	27.2	8.5	22.5	14.6
10935	Subsoil of 10934	Yellow sandy loam, 8 to 30 inches.	.7	3.1	6.2	7.6	36.6	25.0	20.6

MIAMI SAND.

The Miami sand is a light-brown to brown loamy sand, usually from 8 to 16 inches deep, resting upon a subsoil of loose, incoherent yellowish sand of unknown depth. The type is characterized by its loose, sandy texture, and the relatively large proportion of the coarser grades of sand in both soil and subsoil. The soil is slightly heavier in texture than the subsoil owing probably to the more perfect weathering of the sand particles since their deposition, and probably also to the fact that there is more humus incorporated with the soil than with the subsoil.

The Miami sand is found principally in the northeastern part of the area, in the northern part of Stark County, and in the southwestern part of Summit County. It is especially well developed near Clinton and in isolated patches southeast toward Massillon. It is also found bordering the group of lakes south of Akron.

In the vicinity of Clinton the type is level and gently rolling, but in the lake region south of Akron the surface is made up of knolls and ridges, with kettle holes and expanses of lowlands intervening. The soil upon the elevations is lighter colored and lighter in texture than that in the intervening lowlands.

Owing to the loose, porous nature of the soil and subsoil and its usual undulating topography the type is naturally well drained except in the kettle-hole depressions and swampy areas bordering the group of lakes already mentioned.

The Miami sand is both glacial and alluvial in origin. In the valley near Clinton it is purely alluvial, being composed of the sandy materials washed from the adjoining uplands and deposited upon the floor of the valley during spring floods when the stream ran at a higher level than at present. In the lake region some of the type has the appearance of having been laid down as eskers and kames at the close of the Glacial period, while in other places, especially bordering the lakes, it seems to have been formed by wave action when the lakes stood at a higher level.

Wheat, corn, oats, grass, potatoes, truck, and fruit are grown upon this type of soil. Where the type borders the foothills and receives the seepage water from higher ground the crops do much better than in areas lacking this advantage of moisture condition. The average yield for wheat is about 10 bushels per acre. Oats do well only in wet years. Corn will average about 25 bushels per acre. It is only occasionally that a crop of grass is seen. In a good year potatoes do very well, but with the average season the yield is about 75 bushels per acre. If conveniently located as to markets this soil would make an excellent type for truck and fruit farming.

The following table gives the results of mechanical analyses of typical samples of this soil:

Mechanical analyses of Miami sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10942	¼ mile W. of Rex Lake, Summit County.	Brown sand, 0 to 12 inches	8.7	32.8	17.3	21.1	4.7	7.5	7.3
10940	1 mile S. of Clinton.	Brown sandy loam, 0 to 10 inches.	4.3	17.7	25.5	19.8	4.4	17.3	11.4
10941	Subsoil of 10940	Yellow sand, 10 to 40 inches	8.1	25.3	26.4	22.1	6.0	5.8	6.0
10943	Subsoil of 10942	Coarse to medium sandy loam, 12 to 36 inches.	3.7	23.6	17.3	18.9	5.7	19.4	11.2

YAZOO CLAY.

The Yazoo clay consists of about 10 inches of black clay, underlain by from 2 to 8 inches of stiff, impervious, bluish-black clay, below which, to unknown depths, is a stiff impervious blue clay. In the Wooster area this type is found only in a few isolated patches and always as depressions in the valleys and is subject to overflow. The largest body occurs 5 miles south of Wooster in the Killbuck bottom. Its surface is almost flat or slightly basinlike.

When the region was first settled the depressions occupied by this soil were covered with water during most of the year, and a rank aquatic vegetation flourished during the summer. It has only been during the past score or so of years that they have been brought under cultivation, and prior to that time they were either too swampy for any use or served only for pastures during the dry season. Before any crop could be grown deep, wide open ditches with shallower laterals had to be dug, and later tile drains were laid with outlets into the open ditches. Upon thorough drainage this type becomes less sticky and impervious to water, more friable, and more easily worked. Yazoo clay owes its origin to the intermingling of decayed remains of rank swamp and aquatic plants, the wash of fine mineral particles from the hills, and the sediments left by freshets.

The type makes the best corn land in the area, and sometimes yields as high as 100 bushels per acre. It is not suited to wheat because of the spring freshets. It is not adapted to spring grain crops because they grow too rank. Potatoes yield well, but the quality is not good. This soil is best adapted to corn, grass, and pasture.

The following table gives the results of mechanical analyses of typical samples of this soil:

Mechanical analyses of Yazoo clay.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10932	8 miles S. of Wooster.	Dark clay, 0 to 10 inches	Tr.	1.4	0.6	1.8	7.6	40.2	48.9
10930	3¼ miles NW. of Smithville.	Dark-brown clay, 0 to 10 inches.	.0	.8	.6	1.6	7.1	39.4	49.9
10933	Subsoil of 10932	Waxy clay, 10 to 36 inches	Tr.	.6	.3	1.4	5.8	34.0	57.2
10931	Subsoil of 10930	Stiff clay, 10 to 36 inches	Tr.	Tr.	.9	2.8	6.9	26.5	63.8

WAVERLY CLAY.

The soil of the Waverly clay, to a depth of from 9 to 12 inches, is a clay or clay loam, varying in color from brown to dark gray. Usually there is considerable sand in the soil, and when put under cultivation it becomes quite loamy. The subsoil is lighter in color and usually considerably heavier in texture than the soil, and in its lower depths consists of material known locally as "blue clay." Sometimes there are slight elevations in areas of this type that are a little sandier than the typical soil, but such areas are rarely more than an acre or two in extent. Occasionally there are depressions where the soil is darker colored and more clayey than in the true soil, but these are likewise of limited extent and the type, as a whole, is quite uniform in texture.

The Waverly clay is found in the first bottoms along all the larger streams, and, as would be expected, its topography as a whole is rather flat. The areas lie at elevations ranging from 5 to 20 feet above the present stream beds, and vary in width from one-eighth to 1½ miles. The soil is subject to annual inundation, and, owing to obstructions of logs and driftwood, the spring flood waters were formerly held in check during most of the summer. Such is the case at present where the timber has not been cleared off. It is a difficult soil to drain, owing to its slight elevation above the streams and the impervious nature of the subsoil. Much improvement in the drainage conditions has been brought about by digging deep, wide ditches, using steam dredges for the purpose. Into these main ditches the shallower laterals and tile drains are led, and wide areas of the land formerly held in low esteem have been reclaimed and put under cultivation.

Geologically, this soil type is the youngest in the area. Each successive spring freshet carries some of the clay, silt, and sands from the uplands and redeposits them as a thin layer of sediment upon the floor of the valley, so that the type is still in process of formation.

Only a small proportion of the type is under cultivation and a considerable part of it is still covered with the original forest of oak, elm, sycamore, and hickory. The tracts under cultivation have proved to be among the most productive in the area, while others are used largely for meadow and as a pasture for stock during the summer and fall months. A few areas have been in continuous cultivation for over fifty years without the application of fertilizers or manure and are still very productive, the spring freshets tending to rejuvenate the soil year after year. The type is used principally for corn, to which it is especially adapted, the yield in good seasons being 75 bushels per acre. A little wheat is grown, but the soil is too wet for this crop.

The following table gives the results of mechanical analyses of typical samples of this soil:

Mechanical analyses of Waverly clay.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
10922	Rittman	Brown clay, 0 to 12 inches	Tr.	0.6	1.0	4.6	10.1	47.4	36.2
10924	1 mile W. of Wooster.	Brown clay, 0 to 10 inches	0.8	.9	1.0	2.9	6.7	35.4	52.9
10925	Subsoil of 10924	Mottled clay, 10 to 36 inches	.2	.6	.5	2.2	10.1	42.0	44.0
10923	Subsoil of 10922	Mottled clay, 12 to 36 inches	.0	.6	.5	2.5	8.6	41.7	45.8

VOLUSIA SILT LOAM.

The soil of the Volusia silt loam is a brown silt loam with an average depth of 10 inches. The line of demarcation between the soil and the subsoil is quite distinct as to color, but not as to texture. To a depth of about 20 inches the subsoil is a light-brown or yellowish silt loam, only slightly heavier in texture than the soil. Below 20 inches the clay content increases somewhat, and in depressions where underdrainage is imperfect the clay content becomes considerably greater and the color becomes a mottled drab and yellow.

Throughout both soil and subsoil of the Volusia silt loam, and scattered upon the surface, are considerable quantities of shale, sandstone fragments, and gravel, all of which are derived from the underlying formations. There are local variations in the type, depending upon whether it is found on steep valley slopes or on the broad, gently rolling interstream areas, or whether it has been properly farmed or subjected to wasteful methods of cultivation and consequent injury from erosion. As a rule, however, it is a very uniform type, and the one upon which the farmers have been most prosperous.

It is found in one very large, continuous body and other important tracts in Wayne County in the southwestern and south-central parts of the area, and in a few disconnected smaller areas in Stark County, in the southeastern part of the area. It is typically developed in the region between Smithville and Wooster and for several miles west of Wooster outside of the area surveyed. Owing to the loose, loamy nature of this soil and the presence of fragments of sandstone, shale, and gravel, it is naturally a well-drained, easily tilled type. Except in the most level locations it can usually be plowed in the spring earlier than any other upland type in the area. It is not, however, a droughty soil, the deeper subsoil being quite retentive of moisture, which rises readily in times of drought. It is an easy type to erode, and in hilly areas the best farmers exercise great care to keep the fields from gullying. For this reason no plowing is done in the fall, tile drains are laid, and the ravines of cultivated fields are allowed to remain sodded.

In general the Volusia silt loam is a residual soil, derived from the weathering of fine-grained sandstones and shales of the Waverly Group and the Lower Coal Measures. The underlying rocks are usually not far below the surface and can quite often be seen in the road cuts, on the crests of hills, and in quarries. The whole region has been glaciated, but the glacial débris from the north has entered but slightly into the composition of this type, nearly all of the material being of local origin.

Wheat, corn, oats, and fruit are the most important crops of the Volusia silt loam, although it is well adapted to all the varied products suited to the climate. The average yield for wheat is about 20 bushels per acre and yields as high as 30 bushels are not uncommon. Corn, under the best cultural methods, will average 40 or 45 bushels per acre. Oats will yield an average of 50 bushels per acre, although larger yields are often reported. From 100 to 150 bushels of marketable potatoes per acre is the average production of this crop, depending upon the methods of cultivation, location, and season. Little fruit is grown except for home consumption, but a noticeable feature of the type is that every farm has its apple, peach, plum, and cherry trees and grape vines. In some instances the apple and peach orchards are quite large. Considerable timothy and clover hay are grown, but difficulty is frequently experienced with the clover dying out in spots, and again it is difficult to get a suitable stand of the clover seedlings. This, however, has not always been the case, for formerly it was a very good clover soil. By the litmus-paper test in the field the type shows an acid reaction. This acidity may be corrected by lime, as discussed elsewhere.

This type of soil was originally forested with white, red, and black oak and some chestnut.

The price of the Volusia silt loam ranges from $10 to $20 more per acre than that of the Miami clay loam.

The following table gives the results of mechanical analyses of the fine earth of typical samples of this soil:

Mechanical analyses of Volusia silt loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10750	Wooster	Brown silty loam, 0 to 10 inches.	1.4	2.3	1.1	2.1	15.4	60.6	17.1
10850	2 miles N. of Applecreek.	Brown silty loam, 0 to 10 inches.	1.4	2.6	1.8	2.7	6.8	65.8	19.4
10954	2¼ miles SW. of Smithville.	Brown silty loam, 0 to 10 inches.	1.3	1.6	1.0	2.8	7.5	65.4	20.1
10751	Subsoil of 10750 ..	Silty clay loam, 10 to 36 inches.	.3	1.1	.7	1.9	18.5	59.0	18.5
10851	Subsoil of 10850 ..	Light-brown loam, 10 to 36 inches.	3.8	4.4	2.2	4.3	9.7	55.0	20.6
10955	Subsoil of 10954 ..	Yellow silty loam, 10 to 30 inches.	.8	1.6	1.0	2.1	9.1	57.1	27.8

PEAT.

Peat is a mass of roots, sedge grass, moss, etc., in various stages of decay. It is black or brown in color, the latter color predominating in the lower depths. Underlying this mass, the depth of which varies from 2 to 15 feet, is a stiff, impervious blue clay.

This type is found in different parts of the valley of Killbuck Creek and in the region near the lakes in the northeastern part of the area. It occurs sometimes in depressions in the valleys, but more often on low divides between streams. Large areas sometimes mark the place of a former lake. Such was the origin of the areas near Orrville, Creston, and Lodi.

The flat physiography and the underlying impervious clay naturally make the type wet, and thorough draining is necessary before cultivation can be undertaken. Open drains are used almost without exception, and owing to the saturated condition of the soil and the impervious nature of the subsoil the drains are placed with narrow intervals. When drained much of the humus and organic matter gradually disappears and the soil becomes lighter and settles. The settling is due in part to the removal of the water.

The first attempts to reclaim land of this type were discouraging. The best crops can be produced only after the land has been worked two or three years, as even with drainage established it takes some time for the soil to dry out. This lack of immediate returns delayed the reclamation and kept down the price of what is now the most valuable land in the area. Where the Miami sandy loam or the Miami sand lies adjacent to areas of Peat considerable sand is intermingled with the vegetable matter. Such areas grow very profitable crops of huckleberries.

Onions and celery are the crops to which this type is probably best adapted. Large quantities of both of these vegetables are grown, and the yields and quality compare very favorably with those obtained in other regions more famous for the production of such crops.

DRAINAGE.

When the region was first settled, and, in fact, until about sixty years ago, Newmans Swamp, near Orrville; Killbuck Swamp, near Wooster, and Creston Swamp were shallow lakes in the broad, flat, partially filled preglacial channels. Alder and willow grew in and around these lakes, and in places cranberries grew in abundance. As the country became settled and cleared, very marked changes took place in these marshy areas. With the removal of trees and other obstructions the streams receded to their channels, and were finally held there as a result of eroding their own channels deeper. Later, by the construction of deep, wide ditches and shallower laterals and by laying tiles large tracts of these lowlands were reclaimed, and to-day some which were once held in very low esteem are among the highest-priced lands in the area. The areas of Peat for example, which were formerly too wet for any use, are now the highest-priced lands in the area. The asking price is $200 an acre, and the celery and onions grown upon them are said to be equal, in yield per acre and quality, to the Kalamazoo products.

Along the bottoms of all the larger streams of the area there are still larger bodies of land unfitted for anything except mowing lands and pasture. The Waverly clay, locally known as "first bottoms," is usually found in such locations. It is subject to annual inundation. Considerable work is being done at present to facilitate the reclamation of the lowlands in the vicinity of Sterling, where a steam dredge is at work excavating a deep, wide, straight channel for the stream, which heretofore has had a meandering course. The result will be that the spring flood waters will run off much sooner and the stream will gradually deepen its own channel. Farther down the stream, in the vicinity of Rittman, there are thousands of acres which may be reclaimed in the same manner; and unless steps are taken to do so the downstream areas will be more subject to inundation than ever before, because the water will not stand as long upon the upstream flood plains as formerly.

All the other soil types in the area, except the Miami gravelly loam, Miami sandy loam, and Miami sand, are greatly benefited by tile drainage. The difficulty with the types just mentioned is that they are already too porous. Probably 50 per cent of the Miami clay loam and Volusia silt loam on the uplands are tiled. Notwithstanding the loose, loamy nature of the Volusia silt loam, it is greatly improved by tiling in all locations, even where it is quite rolling, for the tiles carry off underground the excess water of heavy rains, and thus tend to prevent erosion of the loose, loamy surface soil. The Miami clay loam is the type which receives the greatest benefit from tiling. In the undrained areas it is called a "cold, wet, late land." After draining it becomes warmer, and therefore can be seeded earlier in the spring. It also becomes more porous, and there is better and more uniform distribution of the soil water throughout the year. It is less subject to drought in the dry season, it works easier, there is a greater certainty of crops, and the yields are larger. Draining makes it a better wheat soil from the fact that the seedlings do not "heave out" so badly in the winter and spring. The areas of the Yazoo clay are also greatly benefited by tiling. The large tile works at Rittman furnish quantities of tile for the area and surrounding country. The materials for the manufacture of tile are near at hand, the source of fuel supply not far distant, and the cost of the finished product is moderate.

SPECIAL SOIL PROBLEM.

At the present time great difficulty is experienced in the Wooster area with the clover crop. Soils on which clover has been successfully grown for over half a century are now in such condition that this crop is wholly or partially a failure. In many instances it is difficult to get a stand, and after that is secured the seedlings often die out in spots throughout the fields. An examination of these spots, made during the survey by the litmus-paper test, reveals the fact that they are quite acid. An examination of the soil adjoining shows that it is acid also, but apparently not so much so as the affected spots.

The acidity of soils is thought by some to be due to the excessive use of acid phosphate. During the last decade a few farmers have been liming their fields, and the result is that clover does very much better.

The acid test was made of the soil of fields which had been limed. Nearly all portions of such fields showed a neutral test, but in places the soil was still slightly acid, probably owing to the fact that not enough lime had been applied. If the productivity of the soil is to be kept up, the growing of clover and other legumes is a matter of great importance; and if the liming of soils is the proper remedy for that condition which now renders the crop in some areas uncertain, it is certainly a practice that should be followed more generally by the farmers in the Wooster area.

AGRICULTURAL CONDITIONS.

The prospering state of agriculture in the Wooster area is shown by the generally thrifty appearance of the farms. The farm buildings as a rule are large and well kept. Frequently the houses are equipped with as many modern conveniences as city homes, having their own waterworks, sewerage systems, etc. The great number of large well-formed draft horses and the abundance of improved farm machinery also attest a flourishing agricultural community, while the generally high price of farm lands and the small number of mortgaged farms are further evidence of the prevailing prosperity.

About 60 per cent of the farms of the area are operated by the owners, the remainder being farmed by tenants on a share or cash basis. The farmers who do not operate their own farms have moved into the nearby villages and towns.

The size of the farms varies from 30 to 200 acres, but the average is about 90 acres. The price of land varies with the type of soil, improvements, and nearness to town. Very little land can be purchased for less than $45 an acre, and some areas are held as high as $200. The Volusia silt loam near Wooster can not be purchased for $100 an acre. The Miami clay loam wherever found is valued from $10 to $15 an acre less than the Volusia silt loam adjoining.

Some labor is hired by the year, the wages ranging from $18 to $25 a month. During the harvesting season of some of the crops considerable help is hired, the usual wage being $2 a day. As a rule, however, the small size of the farms and the employment of modern farm machinery make it possible for the farmer and his family to do the work. In the vicinity of the coal fields the labor conditions have interfered more or less with farming. Some of the farmers work in the mines and neglect their farms, while others do little with their land, the royalty from the underlying coal being sufficient to maintain them comfortably without work.

Wheat, corn, oats, potatoes, timothy and clover, orchard fruits, vegetables, berries, maple sirup, and tobacco are the important products of the Wooster area. A number of carloads of draft horses are shipped annually to the eastern markets, but these are nearly all shipped into the area from Indiana and Illinois when two or three years old and let out by the local horsemen to the farmers to be fed until they are 5 years old, at which age they are in demand in the eastern markets. A few cattle also are bought and fed. The practice of feeding all the hay and straw of the farm and husbanding the barnyard manure has had much to do with maintaining the general productiveness of the soils of the area.

The transportation facilities of the area are very good. The Toledo division of the Wheeling and Lake Erie Railroad extends westward from Massillon to Orrville and then northwest to Creston. The Pittsburg, Fort Wayne and Chicago, with its excellent double-track service, passes through Massillon, Orrville, and Wooster and gives ready communication with the East and the West. The Cleveland, Akron and Columbus gives good service with Cleveland and the southern part of the State. The Cleveland, Loraine and Wheeling connects Massillon, Doylestown, and Sterling. The Baltimore and Ohio passes through Creston and Clinton and then north to Barberton, and the Millersburg branch of the Baltimore and Ohio comes down the Killbuck Valley and touches Wooster. The Erie enters the northern part of the area and connects Burbank, Creston, and Rittman. Besides these railway lines there is a trolley line, with cars running every hour, which connects Wooster with Cleveland, and another line connects Massillon and Canton. The Ohio Canal, which extends across the State from Cleveland to Portsmouth, crosses the eastern part of the area.

In addition to the railways there are good roads laid out on section lines, and some on half-section lines, and these place the farmers within easy reach of the railroads and towns. Substantial, well-built bridges, maintained at the expense of the towns and counties, are usually found across the creeks and rivers.

The products of the farm are readily disposed of in the nearby railroad towns, where there is usually active competition among local buyers.

SOIL SURVEY OF COSHOCTON COUNTY, OHIO.

By **THOMAS D. RICE** and **W. J. GEIB.**

LOCATION AND BOUNDARIES OF THE AREA.

Coshocton County lies east of the center of the State of Ohio, and occupies a portion of the Muskingum Valley. The county covers about 551 square miles, and is divided into 22 townships, 19 of which contain 25 square miles each, while the other 3 are the irregular townships of Jackson, Tuscarawas, and Linton.

Coshocton, the county seat, has a population of about 7,000. The town is noted for the manufacture of metal signs and advertising novelties. There are also foundries, potteries, and brickyards. A large part of the population is engaged in the coal trade.

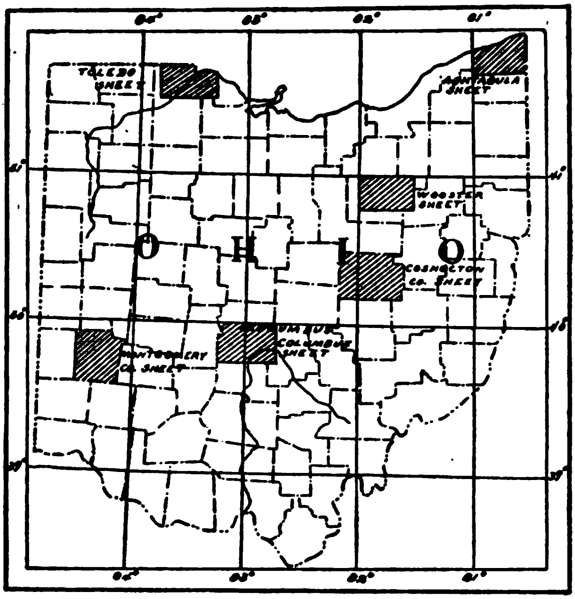

FIG. 23.—Sketch map showing location of the Coshocton County area, Ohio.

West Lafayette, 6 miles east of Coshocton, has a population of about 1,200, and is the center of the most prosperous farming community in the county. Warsaw and Conesville are smaller towns, and there are numerous villages scattered throughout the area.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

By the treaty of Fort McIntosh, concluded with the Delaware and Wyandot nations in 1785, a large tract, including the area surveyed, was ceded to the United States. Later on, in 1798, a tract designated as the United States Military Land District was set aside by Congress to satisfy certain claims of soldiers of the Revolutionary war. This included what is now Coshocton County. The tract was surveyed into townships 5 miles square, then into quarter townships, and later some of these were divided into 100-acre lots for the accommodation of soldiers having claims to that amount of land.

The first settlement in the county was made 4 miles above the "Forks of the Muskingum" in 1800. The next year settlements were made in Oxford, Franklin, and Washington townships. In 1802 a town was laid out—the present site of Coshocton—and called Tuscarawas; when the county was organized in 1811 it became the county seat and took its present name. As originally constituted, Coshocton County embraced what is now Holmes County, extending to the Greenville treaty line, 6 miles north of Millersburg, but that county having been organized in 1824, the limits of Coshocton County were fixed where they now are. The earliest settlers came from Virginia, Maryland, and eastern Pennsylvania, but later New York and western Pennsylvania were largely represented. Small colonies also came directly from Ireland and Germany, and in spite of many drawbacks the population increased steadily, in 1820 numbering 7,086. By 1850 this had grown to 25,670.

The early settlers took up land in the valleys, and there the virgin soil produced large crops of corn, for which staple it was well adapted. It was thought that the uplands were of no value for agricultural purposes, but when the valleys became more thickly settled and the price of land had advanced beyond the reach of those of moderate means, the newcomers were obliged to settle the uplands, which they found would produce good crops of wheat and grass, and which were especially adapted to the raising of live stock.

Before the opening of the Ohio Canal the county had no outlet for produce except over poorly constructed wagon roads to Lake Erie, or by boat down the Muskingum and thence to New Orleans. The country was full of produce for which there was no market. The portion of the canal within Coshocton County was built in 1827–1830. This marked an important epoch in the development of agricultural and other industries. Wheat rose from 25 cents to $1 a bushel, while corn, potatoes, and all other produce advanced in proportion. Until the first railroad was built in the county, in 1855, the canal boats did a thriving business, for all freight was transported by them. After this date, however, the traffic dwindled and only a local business was carried on by the boats. Even this soon died out, and the canal was practically abandoned as a means of transportation. Of late years it has been used to some extent to furnish water power to various manufacturing establishments along its route.

Since its early settlement general farming has been practiced throughout the county. Corn was the principal crop, and as early as the year 1857 more than a million and a half bushels were grown. Wheat ranked next to corn in amount and value. The period of its most successful cultivation was from 1835 to 1850. Later there was serious trouble from winter freezing and other causes, and for twenty years this industry was greatly depressed. Then came a succession of good years, which proved a stimulus, and while the yields were not quite equal to those of the early days, wheat could be profitably grown, and its cultivation is still practiced. Before the civil war tobacco was grown in considerable quantities, but as the farmers all began to grow it, the supply soon exceeded the demand, and its cultivation was quickly abandoned and never taken up again on a commercial scale.

In some sections fruit raising has been successfully practiced for over half a century. In 1878, 446,998 bushels of apples and 69,860 bushels of peaches were grown in the county. In 1901 there were 4,640 acres in apple orchards and 1,834 acres in peach orchards in the county. Washington township was, and is still, in the lead in this industry.

Stock raising early proved to be a profitable business, and sheep especially received attention. By 1878 Coshocton had become one of the leading sheep counties in the State, and that year produced 490,076 pounds of wool. To-day it is the fifth county in the State in number of sheep kept, and the wool clip for 1901 was 17,000 pounds less than 1878. The dairy industry has never been developed to any extent, but beef cattle have been raised with success.

In 1850 a county agricultural society was organized, and a fair has been held each year since that date. This has had a tendency to bring the farmers of the county into closer touch with each other and to stimulate the introduction of better methods and the production of finer animals and larger crops.

Between 1850 and 1870 there was a marked decrease in the population of the county. The same condition has been noted in other counties in Ohio, especially such as were most largely agricultural. The disposition to forsake the farm for the shop, store, and office, the movement to the newer West, and the enlargement of local manufacturing interests of the towns all had to do with the decrease of population in the rural districts. Since 1870, however, there has been a steady growth, not only in the population, but in the development of all industries represented in the area.

CLIMATE.

Warsaw is the only station of the Weather Bureau in Coshocton County where records of temperature and precipitation have been kept, but in the following table data are added for Canal Dover. This station is only a few miles northeast of the Coshocton County line, and has practically the same elevation, so that the figures given may be taken as indicative of the climatic conditions of the area.

Normal monthly and annual temperature and precipitation.

Month.	Warsaw.		Canal Dover.		Month.	Warsaw.		Canal Dover.	
	Temperature.	Precipitation.	Temperature.	Precipitation.		Temperature.	Precipitation.	Temperature.	Precipitation.
	°*F.*	*Inches.*	°*F.*	*Inches.*		°*F.*	*Inches.*	°*F.*	*Inches.*
January	28.1	2.41	28.1	3.25	August	71.6	4.36	71.0	2.22
February	25.3	1.98	26.8	2.80	September	65.9	2.41	63.9	2.35
March	37.6	3.73	39.8	4.54	October	51.6	1.65	50.7	1.89
April	50.8	2.31	49.8	2.86	November	39.6	3.03	40.0	3.32
May	61.7	3.50	60.8	3.58	December	30.0	2.74	31.5	3.20
June	71.2	3.74	68.9	3.30	Year	50.6	36.50	50.3	39.17
July	74.1	4.64	73.0	5.86					

The climate of Coshocton County is that common to the entire eastern and central portions of Ohio, with such slight differences as are incident to variations of altitude. It appears from the above table that during the three winter months an average temperature below the freezing point is maintained. During this time there are periods of intense cold when the mercury may stand below zero for a week or more at a time, sometimes reaching —20° F. During these months grasses and small plants are usually protected by from 6 to 10 inches of snow. Snow may fall until the latter part of April, but the late snows rarely remain on the ground for any length of time. Spring opens suddenly, and it is not often that much damage is done by untimely frosts.

The summers are short but hot, with occasional periods of oppressive heat. The greatest precipitation occurs during the summer months in heavy local showers.'

PHYSIOGRAPHY AND GEOLOGY.

Coshocton County occupies a portion of the great plateau of eastern Ohio. The surface is sharply rolling and in many places rough and hilly, but the hills maintain a general summit level of from 1,100 to 1,200 feet above the sea, and no point of land rises to any noticeable height above the surrounding upland country. The hills have a domelike slope, characteristic of the weathering of the sandy shales of the region, and there are no ridges of any considerable extent.

The entire area is drained by the Muskingum River, which is formed near the center of the county by the confluence of the Walhonding and Tuscarawas rivers. The towns of Coshocton and Roscoe have grown up near the junction of these streams. From this point three beautiful and fertile valleys radiate to the county borders—the Muskingum to the south, the Tuscarawas to the east, and the Walhonding to the west. In addition to the alluvial lands of these valleys there are areas along Killbuck Creek, a tributary of the Walhonding River, where a broad valley extends northward, and along Wills Creek, skirting the southern border of the county, while a strip of such land connects the valley of Wills Creek and the Tuscarawas Valley. The latter is probably a former channel of the Tuscarawas River. It may be seen west of West Lafayette, extending along the present valley of the Tuscarawas, from which it is separated by a broken range of hills. It extends southward from the town of West Lafayette and merges into the valley of Wills Creek near the town of Plainfield. The slopes of this valley are several miles in width, and the alluvial land ranges in width from one-fourth mile to 1 mile.

The bottoms along the rivers average almost a mile in width. The sedimentary materials of which they have been built up fall into two general subdivisions as regards position and texture. They are arranged in terraces, five of which may be counted in some places, but usually only three are well marked. The lower bottoms are practically level and so little elevated above the streams that they are subject to overflow in periods of high water. The surface of the land may be washed away or added to by the floods. Such variations may amount to 3 or 4 inches during a single flood. The average deposit is a silty loam, but quite near the river beds of sand or gravel may be thrown down. The second grade of sedimentary deposits occupies the higher terraces above the present limits of overflow. These terraces stand from 40 to 60 feet above the level of the river and have a gently rolling surface. The composing material is a coarse, gravelly loam, with occasional small beds of almost pure gravel.

The hills, with their covering of residual material, rise abruptly above the comparatively level valleys. In some places, as in the upper valley of the Walhonding River, the rocks stand up as cliffs above the stream.

Coshocton County lies in the great Appalachian bituminous coal belt, near its western border. The entire area is underlain by sandstones, sandy shales, and limestones of the Carboniferous age. The soils, with the exception of the river sediments already described, have been derived from the weathering of these rocks. Over the greater part of the county the prevailing rock is a sandstone or sandy shale interspersed with thinner strata of limestone and seams of coal. This formation represents the Lower Coal Measures. The position of the strata is so nearly horizontal that the dip can not be determined, even in a distance of several miles. On account of this feature it is an easy task to trace the coal beds from hill to hill. Along the upper part of the Walhonding River the barren sandstones of the Waverly group, the lowest subdivison of the Carboniferous, are exposed. No difference is noticeable in the physical properties or productiveness of the soil as the rock changes from one formation to another.

Several coal seams outcrop in Coshocton County, but only one is of any great value. While coal may be seen in nearly every hill, the thickness is variable and the extent of the bed uncertain. In some places the bed attains a thickness of more than 3 feet; in others it pinches out entirely. This discourages mining on a large scale over most of the county, but the easily mined deposits on nearly every farm have given the farmers an abundant supply of fuel for home use, and many of them derive an income by mining coal for the market when the farm work is not pressing.

The sandstone of the area is shaly and easily crushed, and is not well adapted to building purposes. There are several quarries, however, which produce a fair quality of stone for rough building.

Coshocton County lies west of the oil belt. Natural gas has been found between Coshocton and West Lafayette, and the latter town is supplied from the well. The other economic products of a geological nature are deposits of brick and pottery clays, which permit the profitable operation of large plants in different parts of the county.

SOILS.

The soils of Coshocton County have been divided into three types. The Dekalb silt loam occupies the extensive upland areas, and the Miami loam and Miami gravelly loam make up the soils of the river bottoms. The area of each type, with its percentage of the total area, is shown in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.
Dekalb silt loam	320,064	90.7
Miami loam	17,600	4.8
Miami gravelly loam	15,104	4.3
Total	352,768	

DEKALB SILT LOAM.

The Dekalb silt loam occupies the whole of Coshocton County, with the exception of the comparatively narrow stream valleys, and comprises 90.7 per cent of the total area. The texture of the soil is remarkably uniform throughout the area, there being little variation save the slight local changes resulting from differences of topography and drainage conditions. The soil is a mellow loam or silty loam of brown or yellow color. The sand constituent is of the finer grades, and this, with the large silt content, gives the soil the character of a mellow silty loam of excellent physical character. Organic matter is rarely lacking, as the uplands are kept in grasses a large part of the time and leguminous crops have a place where cultivation is continuous. The soil ranges in depth from 8 to 20 inches, with an average depth of 14 inches. The line between soil and subsoil is nowhere sharply drawn. The subsoil may be described as ranging from a silty clay loam to clay. It is not plastic or tenacious. It has a characteristic yellow color, lighter than that of the soil, owing to the lack of organic matter. Over a large part of the area the unweathered rock is encountered at a depth of less than 3 feet. Nearly everywhere fragments of shaly sandstone are scattered through the soil and strewn over the surface.

There are two variations of the type, neither of them being of any great importance. In a few very restricted areas, south of West Lafayette, the sandy shales are somewhat micaceous, and a very fine, smooth loam results from their weathering. In other places loosely cemented sandstones, disintegrating rapidly under the action of the weather, give a more sandy phase of the type.

The Dekalb silt loam covers the whole of the hilly upland already described. There is no considerable extent of level land in the area occupied by this type. The country is more rough and hilly near the streams. The hills rise sharply from the flood plains, and those nearest the water courses have steeply eroded slopes. Farther back from this region of rapid erosion the country presents a more rolling appearance, which characterizes the greater part of the topography of this type.

Naturally such a topography relieves the farmer of all the difficulties of drainage. Nowhere in the region is it necessary to resort to tile drainage. The underlying sandstones, as a rule, are porous and offer no impediment to the rapid percolation of the soil water. A large part of the rainfall sinks immediately into the ground, to reappear below in the numerous springs which are a common feature of the hilly country. The soil is not retentive of moisture, and damage results from any protracted drought. The rainfall is, however, so uniformly distributed throughout the year that damage seldom results from this cause.

The tendency to wash and gully is not so great as in many soils of similar topography, but it is still an evil that must be guarded against. It is not advisable to put the very steep hillsides in any crop that requires cultivation. The wild grasses which make up the pasturage hold the soil very effectively. Timothy may also be grown on the steeper hillsides. Where the land is cultivated no trouble is experienced on hills of moderate slope if contour plowing is practiced.

The Dekalb silt loam is a residual soil, formed by the decomposition of the sandstones, sandy shales, and limestones of the region. Of these the sandstone seems to have influenced the texture of the soil to a greater extent than the others. The limestone occurs in thin strata, and as a rule the effect on the texture of the soil where these strata outcrop is not noticeable. The so-called limestone soils are considered slightly more productive, especially of grasses, than the soils derived from the breaking down of the sandstones, but no textural differences can be detected. The original rocks that made up the Dekalb silt loam areas contained some iron, and this is manifested in the soil by occasional iron concretions. In some places the accumulations of iron have formed crusts or bodies of kidney ore, but in no locality in sufficient quantity either to be of any economic value or to have any effect on the cultivation of the land.

A general and diversified system of farming is practiced on the Dekalb silt loam. Of the cultivated crops corn, wheat, and timothy are the most important. The yields are not so large as on the river lands, but the farmer is reasonably certain of a fair crop. The raising of sheep and cattle is largely confined to this type of soil. Much of the land is so hilly and stony as to be unfit for cultivation, but the soil is well adapted to grasses, so that the greater part of nearly every farm is devoted to pasture.

In the extremely rough portions of the county the land is still in forests of hardwood. The scarcity of timber has recently caused lumbermen to come into the northern part of the county to get out ties and posts.

The following table gives mechanical analyses of typical samples of the fine earth of the Dekalb silt loam:

Mechanical analyses of Dekalb silt loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11021	3 miles W. of Coshocton.	Loam, 0 to 14 inches	0.9	5.4	6.7	8.6	8.2	53.5	16.3
11019	2 miles S. of Bakersville.	Brown loam, 0 to 12 inches.	.6	2.9	4.1	22.2	12.7	38.5	19.1
11017	4 miles N. of Coshocton.	Clayey silt, 0 to 8 inches	1.1	1.3	.7	1.7	7.3	66.6	21.2
11015	1 mile S. of West Lafayette.	Clayey silt, 0 to 8 inches	.8	1.5	.8	1.8	9.2	63.1	22.8
11020	Subsoil of 11019	Silty clay loam, 12 to 36 inches.	1.2	2.6	3.1	15.1	12.9	42.6	22.3
11022	Subsoil of 11021	Silty clay loam, 14 to 36 inches.	1.2	4.6	4.0	5.4	6.4	50.3	28.1
11018	Subsoil of 11017	Silty clay loam, 8 to 36 inches.	1.7	2.5	1.1	4.7	16.6	39.5	33.8
11016	Subsoil of 11015	Silty clay, 8 to 36 inches	1.4	2.1	.9	1.3	4.2	41.3	48.9

MIAMI LOAM.

The Miami loam is very uniform in texture for a soil which has been deposited in times of flood by river currents of varying velocities. In its usual development the soil is a loam to a depth ranging from 10 to 20 inches, the average depth being probably 12 inches. The soil is a dark brown in color. The fine and very fine sand which make up the coarser portions of the Miami loam are so combined with silt and clay as to give a soil of excellent tilth. There is always present a good proportion of organic matter to a depth of from 6 to 8 inches. This is especially evident where the land has been devoted for some time to clover, timothy, and the pasture grasses, as humus is well retained. The subsoil is a reddish-brown loam, lighter in color than the soil, as it lacks the organic matter found near the surface. The upper part of the subsoil is usually a clay loam, which becomes lighter with depth. There is often, however, no change in texture between soil and subsoil.

The Miami loam occurs as narrow strips along the Muskingum River and its larger tributaries—the Tuscarawas and Walhonding—as well as along several smaller streams which have developed flood plains. It occurs on the indistinctly marked lower lying terraces, some of which are subject to overflow in times of high water. These terraces may be flat or gently rolling, and may be broken by small gravel knolls, remnants of the older terraces which have not been entirely removed. Near the river gravel beds occur as recent deposits from the overflow.

In times of average rainfall little trouble is experienced by the farmers in draining the Miami loam. In seasons of protracted rainfall the rivers overflow their banks and submerge the lower levels occupied by this type. If the high water prevails until late in the spring, farming operations are sometimes seriously retarded, as it is difficult to get the soil drained in time to put in a corn crop. The drainage is rapid, however, when the land is once free of standing water. Tile drains are found useful in some places to hasten the removal of the soil water, but their use is by no means general. The upper and more elevated areas of this type are well drained, and the soil is ready for the plow soon after a rain.

The Miami loam is conceded to be the best corn land of the area, and the valleys of the Muskingum and the other large streams of Coshocton County have long been famous for their production of corn. It is claimed by many farmers that the land has deteriorated in productiveness within the last few years, and this to a greater degree than the crops removed would seem to justify, as the soil is constantly recruited by flood deposits. The statement of average yields for the last thirty years does not conclusively verify this view. It is more likely that the occasional short crops are due to climatic conditions or to some unfavorable physical condition of the soil, rather than to any lack of fertility in the soil or in the sediments now being deposited.

The yield of corn is sometimes as much as 60 to 80 bushels per acre. There is some fluctuation in the average yield from year to year, but never what might be termed a failure of crops. Timothy hay is produced in large quantities. Clover is grown to a limited extent. Alfalfa has been tried and found to grow well on this type of soil. On account of its productiveness and easy tillage, the Miami loam is more generally in cultivation than the other types of the area, and little of it is given up to pasture; hence there is less stock raising and more of the hay crop is sold. Tobacco was formerly grown on this type of soil. The plant made a rank growth and the leaf was heavy and dark in color. When the market demanded a lighter quality of tobacco its growth was discontinued and the industry ceased in Coshocton County.

With the exception of stable manure, no fertilizers are used in Coshocton County. The deposits over the river bottoms during the winter months should maintain the soil fertility indefinitely without the necessity of resorting to commercial fertilizers.

The following table gives mechanical analyses of typical samples of the Miami loam:

Mechanical analyses of Miami loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11025	2 miles W. of Warsaw.	Brown loam, 0 to 18 inches.	0.2	1.0	1.1	5.0	20.2	50.9	21.5
11027	1 mile S. of Conesville.	Brown silty loam, 0 to 18 inches.	.0	.1	.1	1.9	12.2	60.9	24.8
11026	Subsoil of 11025	Loam, 18 to 36 inches	.2	.8	1.0	5.1	14.1	56.3	22.4
11028	Subsoil of 11027	Clay loam, 18 to 36 inches	.0	.0	.1	2.9	19.7	54.0	23.5

MIAMI GRAVELLY LOAM.

The soil proper of the Miami gravelly loam, to an average depth of 10 inches, is a coarse brown or reddish-brown sandy loam. The subsoil is usually a red loam, containing more clay than the soil. The clay content is small, but sufficient to give the subsoil a slightly sticky property. In some cases masses of gravel are found at a depth of 30 inches. Both soil and subsoil are interspersed with waterworn gravel. The greater part of this gravel is sandstone, but limestone, granite, and occasional quartz particles indicate that the material is not of local origin. Throughout the cultivated portion of the terraces the proportion of gravel ranges from 10 to 30 per cent, but there are small areas where there is little, if any, fine material between the pebbles. These deposits have been utilized to some extent to improve the public roads, and where loam is mixed with the gravel an excellent roadbed is secured.

The Miami gravelly loam occupies the higher terraces along the larger streams. There are two areas where the type is extensively developed. The larger of these is near West Lafayette, on what is known as White Eyes Plain, which is formed where an ancient and disused stream valley runs parallel to the Tuscarawas Valley and finally merges into it. The second area is found around Coshocton, and the broad, level terrace of this material forms a beautiful location for the town. There are numerous smaller areas along the river bottoms. In many places all that is left of the gravelly terrace is a fringe along the hillsides, too narrow to be indicated on the soil map.

The larger areas of the Miami gravelly loam are found on the highest terrace of the series occurring along the streams of the area. The next terrace, where present, has a considerable area, but usually it is mixed with other soils and is not so true to the type as the soil of the highest terraces. The surface of these areas lies from 40 to 60 feet above the bed of the river, the land being for the most part slightly rolling.

The elevation of the terraces above the river and the character of the materials composing them combine to give the type good drainage. The soil is therefore warm and crops start early in the spring, which is a valuable feature when the spring is at all backward. The power of retaining moisture, however, is weak, and this soil is the first to suffer in case of drought. Fortunately there is seldom serious loss from this cause.

The varied character of the materials composing the Miami gravelly loam and the subangular shape of many of the bowlders indicate that it has been derived from glacial material. It is probable that during the latter part of the Glacial period the swollen streams brought down the débris from the northern part of the State and partly filled the stream valleys of Coshocton County. Subsequent erosion has removed the greater part of this deposit and left the gravelly areas in their present shape.

The early settlers regarded the Miami gravelly loam as leachy and unfit for farming, so that the greater part of this type was left in its native growth of hardwood timber. When land became more valuable this type was brought under cultivation and soon ranked next to the Miami loam in value. Of the cultivated crops, corn is perhaps the most extensively grown and yields from 40 to 60 bushels per acre. Oats are widely grown and the yields are good. The soil is well adapted to alfalfa. Wheat was formerly grown on this soil, but the droughts and insect enemies, which affected the wheat crop so unfavorably throughout the county, were especially harmful on this type of soil. At present the acreage is small and the yields are poor.

The Miami gravelly loam is well adapted to truck. It is probable that as the manufacturing population of the towns increases a considerable number of farmers may profit by growing vegetables for the local markets. At the present time the demand is small, and if such products were shipped to the large cities of the State they would come into competition with truck grown on more favorably located areas of the same type of soil.

The following table gives mechanical analyses of typical samples of the fine earth of this soil:

Mechanical analyses of Miami gravelly loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11065	¼ mile W. of West Lafayette.	Coarse sandy loam, 0 to 10 inches.	3.3	16.2	18.1	17.8	4.9	29.9	10.2
11063	¼ mile S. of West Lafayette.	Coarse sandy loam, 0 to 10 inches.	9.7	20.3	16.6	11.2	4.2	26.7	11.2
11064	Subsoil of 11063....	Brown sandy loam, 10 to 36 inches.	7.1	18.1	15.5	10.7	3.6	33.4	11.6
11066	Subsoil of 11065....	Coarse sandy loam, 10 to 36 inches.	6.6	12.2	11.2	15.1	6.7	32.6	15.5

AGRICULTURAL CONDITIONS.

While Coshocton does not rank with the best of the Ohio counties in the sum total of its agricultural wealth, its agricultural interests are very important and still hold the first place among its industries. A most pleasing feature of the economic conditions which prevail in the county is the comparatively equal distribution of wealth among the farmers. As a general rule they own the land they cultivate, and a long tenure has enabled each to secure on his place the necessary buildings, implements, and all things required for comfortable living. The barns and other farm buildings are not large or expensive, but are well constructed and suitable to the needs of the present system of agriculture. The dwellings are usually comfortable two-storied frame buildings. Many new houses have been erected within the last two years, but the log cabin of the early settler may be seen in use in many parts of the county. Slate is invariably used as a roofing material for both dwellings and farm buildings. The general appearance of the country is indicative of prosperity and contentment.

The conditions of agriculture throughout the area are fixed. Fertile but hilly farms, such as cover a large part of the area, have naturally favored a system of general farming, in which the raising of sheep and cattle has held a large place. The variations in the relative proportions of land devoted to pasture and to the production of crops are the only changes which take place in the operations of the individual farmer from year to year. The surplus of produce which the farmer can convert directly into cash is small. As a consequence, he does not have money at certain times, like the farmer who grows a money crop, but the small returns and the constant investment of capital conduce to economy and conservative management, which result in prosperity. The owners of the bottom land have, on an average, secured the largest returns for their labor, and the most prosperous part of the county is the valley of the Tuscarawas around West Lafayette. There is no unproductive land in the county, but there are tracts so rough and hilly as to prevent cultivation. This is the case in part of the northwestern corner of the county, and here the country presents the least prosperous appearance.

A large proportion of the Coshocton County farmers are landowners. Some land is held on the share-tenant system, but this is usually done by a farmer who has not sufficient lands for his needs, or where the land rented possesses advantages over his own. The holding of large tracts of lands for rent is exceptional. The land is, to a very large extent, in the possession of the descendants of the early settlers. The farmers, and in fact the whole population, are largely of English descent. The only important foreign element is the small proportion of Germans, most of whom are farmers. There have been migrations to the county on several occasions, but there has also been a steady movement away from the farms to the Western lands and to the cities. This movement has only removed the surplus population, and in no case have farms been abandoned or left out of cultivation. When the cheap Western lands were thrown on the market Coshocton County, in common with all the Eastern communities, experienced a decrease in land values, but since the readjustment has taken place there has been a steady increase in the price of farming land. This price varies widely, according to location and agricultural value. The patches of stony, hilly land are almost worthless, while the level river bottoms often bring over $100 an acre. The average price of a good upland farm is about $25 an acre, and $75 an acre is a fair average for the river lands.

The county is divided by the rectangular system into townships of 25 square sections of 640 acres each. The farms are rectangular subdivisions of these sections. The county is more than one hundred years old as regards agricultural development, and the farms have been subdivided almost to the limit of profit in the kind of agriculture practiced. The average farm contains about 100 acres. This is not large when the rough and uncleared land and the large acreage devoted to pasture are considered. As farming land is not held for speculation, each farmer holds only what he can cultivate with the labor at his disposal.

The labor problem does not seriously affect the agriculture of Coshocton County, as very little hired labor is employed on the farms. The system of agriculture requiring but a small acreage of cultivated crops, the farmer is enabled, with the help of his family, to perform the necessary labor of the farm. The price of labor when employed is not high, the usual wage being $15 to $17 a month with board. The mining and manufacturing enterprises which have sprung up in the county have had a natural tendency to increase the wages of all classes of labor. In all, about 1,200 miners are employed in the coal mines, in many cases by the farmers. The miners contend for the scale of wages in force throughout the bituminous coal region. Laborers of all classes are, as a rule, native born, intelligent, and efficient.

The most important crops of the area are corn, hay, and wheat, in the order named. The average annual production of corn is more than 1,000,000 bushels. The greater part of this amount is grown on the river lands. The uplands are not so productive of corn. The average yield for the entire county is 32 bushels per acre.

Wheat was once grown to a greater extent than at present, but frequent failures have discouraged the growing of the crop to some extent. Although the acreage is still about equal to that of corn, the yield is small, the average being less than 12 bushels per acre. Oats are grown to some extent and yield well.

Both timothy and clover hay are grown. Timothy is perhaps better adapted to all the types of soil. Small fields of alfalfa in good condition may be seen in different parts of the county, showing the possibilities of this crop if it should ever be considered advisable to grow alfalfa in preference to the present hay crops.

Nearly all the hay and grain grown in the area is fed to live stock and marketed in the form of animal products. The cattle and sheep are of good breeds and have every evidence of being well cared for. At one time Coshocton stood first among the sheep-raising counties of Ohio, and even now only four counties in the State have a greater number of sheep. The sheep are mostly of the fine-wool breeds.

Cattle are raised chiefly for beef and to supply butter and milk for home needs. It is a remarkable and unfortunate fact that in a country so admirably adapted to grazing the dairy products should be barely sufficient to supply the needs of the local markets, and sometimes inadequate even for this purpose. This can hardly be accounted for by lack of markets, for, besides the possibilities of export to the neighboring towns, Coshocton has a growing demand for milk and butter. Only a few small dairies have sprung up to meet this demand, though they are said to make a good profit. There is, however, a lack of creameries to take the milk from the farms throughout the county.

Coshocton County is well provided with transportation facilities. The wagon roads do not follow the section lines, but are well distributed, so as to reach nearly every farm. The condition of these roads would be much better if they had been laid out to follow the contours of the hills, but as this is not the case they are generally hilly and uneven. The drainage is good, however, and the roads dry off quickly after rains. With a reasonable amount of work the roads may be kept in fair condition throughout the year.

The railroads are also well distributed. Four lines cross the area. The main double-track line of the Pennsylvania Railroad between Pittsburg and Columbus comes into Coshocton from the east and turns south along the Muskingum Valley. A line of the Wheeling and Lake Erie Railroad also passes through Coshocton, running north and south. A branch of the Pennsylvania traverses the Walhonding Valley west from Coshocton, and a north and south branch of the Cleveland, Akron and Columbus Railroad passes through Warsaw. The canals were once a great factor in the transportation problem of the area, but they have now been completely abandoned on account of the competition of the railroads.

Coshocton is the best market of the area for all kinds of country produce. The town is backward, however, in providing a convenient market. On Wednesdays and Saturdays, which are market days, the farmers and local dealers dispose of their produce from wagons or hastily constructed shelters on the curb around the public square. Of course, on rainy days the crowd of sellers is small, and housekeepers are much annoyed by their inability to buy supplies. The increasing demand at Coshocton for all kinds of farm and dairy products should cause the town to put every means at the disposal of the farmer to have these commodities supplied by the surrounding country, and to prevent their importation from other counties, which has been resorted to within the last few years.

SOIL SURVEY OF THE MUNISING AREA, MICHIGAN.

By **THOMAS D. RICE** and **W. J. GEIB.**

LOCATION AND BOUNDARIES OF THE AREA.

The Munising area lies in the north-central part of the upper peninsula of Michigan, and borders the southern shore of Lake Superior. It comprises all of the northern part of Alger County, with the exception of Burt Township, and includes T. 46 N. to T. 48 N., R. 17 W. to R. 22 W., inclusive. Grand Island, with an area of about 13,000 acres, and several smaller islands near the coast are a part of the area surveyed. The total land surface of the area is 260,608 acres, or, approximately, 407 square miles.

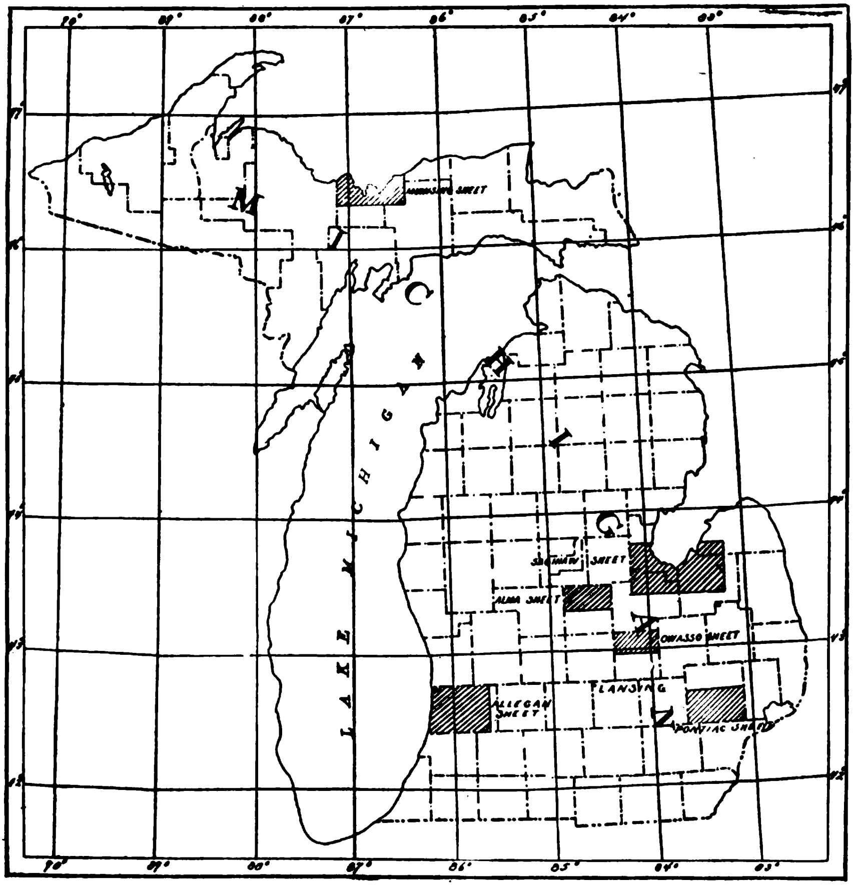

FIG. 24.—Sketch map showing location of the Munising area, Michigan.

Munising, a town of about 3,000 inhabitants, is the county seat of

Alger County. It has a splendid location on Munising Bay, which is the best natural harbor on the Great Lakes. Chatham, Wetmore, Autrain, and Shingleton are small towns engaged principally in the lumber business.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Farming has not yet become the occupation of any considerable number of the inhabitants of the Munising area, yet the possibilities of the soil have been demonstrated and a beginning made that augurs well for future development. Alger County was formed in 1885 from a part of Schoolcraft County, and Autrain, the largest lumbering village of the new county, was chosen as the county seat. In order to understand properly the subsequent development of the county it is necessary to know the conditions that prevailed at that time and to understand something of the earlier history of the county. The first commercial enterprise in the area was the marketing of the pine timber, but as there was little pine in the northern part of the present county of Alger this industry was short lived. Later the demand for charcoal to be used in the manufacture of charcoal pig iron led to the consumption of vast quantities of hardwood. Iron was made at two points on Munising Bay, for which the charcoal was prepared in the vicinity, while the ore was brought by water from the iron region about Marquette. When the available timber was consumed the manufacture of iron was transferred to the vicinity of the iron mines, but the burning of charcoal continued to be an important industry of the area until after the formation of Alger County. In the meantime other lumbering industries had started. Cedar was cut for ties, poles, and posts, and the hardwoods for lumber for the wood-working plants. The construction in the iron regions of large charcoal furnaces for the destructive distillation of the wood and the utilization of the by-products made the smaller kilns unprofitable, and it is now necessary to transport the wood to the furnace. The Munising Railway was built in 1895, largely for the purpose of exploiting the dense hardwood forests through which it passes. The town of Munising grew up at the railroad terminal on Munising Bay, and in 1900 the county seat was removed from Autrain to Munising.

Agriculture was begun in a small way about the lumbering towns, but as few of the inhabitants made agriculture their sole occupation the spread of farms was slow. Too often homesteads were taken in the public lands, to be abandoned as soon as the timber could be sold. The little farming that was done was so inefficient that it was productive of no good results and discouraged prospective immigrants. In 1900 the legislature established an experiment station on the upper peninsula, and Chatham was chosen as the site. The resources of the station have been small, but under efficient management much has been done to demonstrate the agricultural possibilities of the region. Encouraged by the results of these experiments, settlers are coming in and taking up and clearing land in the vicinity of Chatham.

The farming population of the area is composed of a small proportion of native-born farmers, mostly from the southern part of the State, and a larger foreign element, chiefly immigrants from Sweden, Norway, and Finland. These people, as a rule, are industrious and thrifty, but as most of them had no capital to begin with progress has necessarily been slow.

CLIMATE.

No complete or extended weather records have been kept in the Munising area. Observations are now taken at two points, Wetmore and Chatham, but as continuous records have been kept only a short time normals have not yet been established. The table given below is compiled from the records of the Weather Bureau stations at Marquette, on Lake Superior, and Manistique, on Lake Michigan, and may be considered as fairly representative of climatic conditions in the area surveyed.

Normal monthly and annual temperature and precipitation.

Month.	Marquette.		Manistique.		Month.	Marquette.		Manistique.	
	Temperature.	Precipitation.	Temperature.	Precipitation.		Temperature.	Precipitation.	Temperature.	Precipitation.
	° *F.*	*Inches.*	° *F.*	*Inches.*		° *F.*	*Inches.*	° *F.*	*Inches.*
January	16.0	2.04	20.2	1.52	August	63.6	2.89	63.6	3.15
February	17.1	1.78	16.3	1.41	September	56.8	3.88	57.4	2.73
March	23.2	1.84	23.1	1.89	October	45.1	3.26	44.3	3.72
April	37.2	2.01	38.7	2.46	November	31.4	2.72	33.8	2.53
May	49.0	2.98	49.1	3.49	December	22.8	2.46	22.5	1.47
June	59.0	3.51	57.6	4.16	Year	40.5	32.37	40.9	31.97
July	64.9	3.00	64.1	3.44					

It will be seen that the annual precipitation is not heavy, but is well distributed throughout the growing season. Long droughts during the summer months are unknown, and to this fact is due the uniform success that attends the cultivation of the sandy soils of the area.

The upper peninsula of Michigan has a wide range of temperature between the most intense cold of winter and the extreme heat of summer. The brief records of the experiment station at Chatham show a maximum of 92° and a minimum of —30° F. The mean annual for the region is less than 41° F. For four and often five months of the year the normal average temperature is below freezing. The summers are moderately warm, except for occasional hot days. The nights are nearly always cool. Killing frosts may occur as early as the middle of September. Snow falls in November or the first part of December, and the smaller streams and lakes are soon frozen over. In Lake Superior ice does not form, even along the shores, until January, but the ice, in the shape of floes driven across the lake by the north winds, may remain until the first or middle of June, and the water is cold throughout the summer.

While the length and coldness of the winters may discourage the immigration of a farming population from regions farther south, there are certain favorable climatic features which counteract in a large measure such disadvantages and guarantee to the farmer fully as large profits in many lines of agriculture as may be secured in good farming communities elsewhere. The winter may be said to begin with a heavy fall of snow, which remains continuously on the ground until late in the spring, accumulating at times to a depth of 3 or 4 feet. The effect of this mantle of snow is to prevent the freezing of the ground and to protect tender vegetation that would otherwise be killed, as is the case in regions farther south where this protection is lacking when cold weather sets in. The importance of this feature is that grasses can get an early start in the spring, the conditions are favorable for the growth of winter wheat, making it a safe and remunerative crop, and root crops may be safely left in the ground all winter. The fall planting of potatoes has been successfully practiced by the Chatham station. Sugar beets left over winter seem to lose neither in weight nor in sugar content. The influence of this fact upon the development of the sugar-beet industry in this region will be discussed in another chapter. Another effect of the deep snows is to check the hasty growth of vegetation in the spring before the danger of killing frost is past. The lake also has a tendency to even the temperature at this time and retard plant growth. The warm weather finally comes very suddenly, and as the ground is entirely free from frost, plants put forth a wonderful growth and crops mature so quickly as to offset the shortness of the growing season.

PHYSIOGRAPHY AND GEOLOGY.

The Munising area is a part of the region which was scoured off by the encroachment of the great ice sheet during the Glacial period, covered by the débris left by the retreat of the ice, and subsequently altered by the atmospheric agencies of erosion. These processes have produced a wide variation in topography. In some parts of the area the hills are gently rolling; in others, rough and precipitous; and there are nowhere any considerable areas of level land aside from the swamps and marshes. The area attains in places an elevation of about 400 feet above Lake Superior. This rise in elevation is not gradual, but at intervals steep slopes lead to higher general levels, which gives to the topography a general terracelike formation.

Beginning with Lake Superior we find an irregular shore line faced along the greater part of its length by cliffs of sandstone rising abruptly from the water's edge. These cliffs, ranging from a few feet to nearly 200 feet in height, are but the margin of a great sandstone plateau. The greatest height of the cliffs is attained at the Pictured Rocks. At only a few places along the entire coast is the rocky wall broken so as to allow an easy approach to the water's edge. The beach formation occurs near the mouths of some of the small streams, and consists of a coarse yellow sand, which is described in this report as Dunesand. Above it are loose piles of a similar sand, slightly cemented and made stationary by a sparse growth of vegetation. Farther back are long, narrow, parallel ridges of the sand, on which a considerable growth of grasses, shrubs, and even forest trees has taken a stand. These low-lying littoral deposits are inclosed by steep hills, composed either of the sandstone formation or of loose glacial drift. At the top of the plateaulike formation we find the sandstone covered nearly everywhere by unconsolidated drift material to a greater or less depth. Areas where the overlying material is thin and the sandstone outcrops so frequently as to prevent cultivation have been indicated on the soil map as Rough stony land.

The drift over much of the area is of great depth; it reaches to the summits of the highest hills and covers the slopes to the bottom, some of the hills being composed entirely of it. In composition the drift varies from a fine clay to the coarsest sands and gravels. No rule can be laid down for the occurrence of the several grades of material, as beds of sand and of sandy loams alternate within short distances, but as a rule one texture is predominant over extensive areas and gives a general character to the surface soil. Three types of soil have been recognized and mapped in the purely glacial deposits—the Miami sand, the Miami sandy loam, and the Superior clay.

The sandstone has not weathered sufficiently to affect the character of the drift soils, but its weathered product enters into the composition of the thin soil of the Rough stony land. This sandstone is the characteristic red coarse-grained sandstone of the Potsdam formation of the Cambrian. It is overlapped in the southern part of the area by the Calciferous group of the Silurian age, which is here represented by a sandy dolomite. The drift materials cover the Calciferous to such an extent that in only a few areas about Chatham does the rock outcrop sufficiently to have its weathered products modify the surface soil. The soil derived wholly or in part from the dolomite has been called the Fort Payne sandy loam.

The area has no general drainage system. The greater part of the rainfall finds its way to Lake Superior by a number of small streams, of which Sable, Rock, and Train rivers and Millers Creek are the most important. Both the southeastern and southwestern parts of the area surveyed are drained southward toward Lake Michigan. The streams of the area have winding courses through the hills and, as a rule, have sharply cut channels.

It would seem that with a hilly topography and pervious soils the entire country should be completely drained, but such is not the case. The area is characterized by a feature of topography developed in glacial regions, in which depressions formed during the retreat of the glacier or due to post-Glacial erosion have been converted into lakes, marshes, and swamps. The swamps, usually along streams, have been filled with beds of muck and peat. The small lakes are fast being filled with organic matter and sediments, and the existence of numerous small swamp areas indicates that in some cases the filling-in process has been nearly completed.

With the exception of the marshes the entire area was originally forested. The beach sand supported a sparse but valuable growth of pine. On the loamy soils of the uplands were heavy forests of hardwoods, including maple, elm, birch, ash, cherry, and red oak, while on the more sandy soils the hemlock and an occasional pine were found in addition to the hardwoods, and on the very sandy soils of the pine plains the pine alone was found. The swamps were and are still covered by a dense growth of cedar, tamarack, and ash.

SOILS.

The soils of the Munising area have been divided into eight types. The soils grade into one another so frequently that it was often difficult to determine their boundaries, and the difficulty was further increased by the heavy forests and the lack of roads over a large part of the area.

The following table shows the extent of each type and the percentage of the total area which it occupies:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Miami sand	166,464	63.9	Dunesand	7,424	2.8
Miami sandy loam	39,552	15.2	Superior clay	704	.3
Muck	20,480	7.8	Marsh	704	.3
Rough, stony land	17,344	6.7	Total	260,608	
Fort Payne sandy loam	7,936	3.0			

ROUGH STONY LAND.

The term Rough stony land has been applied to areas that are rough, broken, and so covered with rock outcrops and broken stone that cultivation is extremely difficult or impossible. Such areas are found in the northeastern part of Alger County, where the glacial drift is so thin as to allow the exposure of the underlying rock on every hillside.

The largest and only important area of this type lies between Sand and Rock rivers, on both sides of the Duluth, South Shore and Atlantic Railroad. In this region, wherever the streams have cut deep ravines or railroad cuts have been made, it can be seen that the hills are composed of solid sandstone of the Potsdam formation. The bare rock outcrops on the surface are never of any great extent. In some places the undisturbed rock is quite near the surface and covered by only a few inches of soil and vegetable mold, but it is more common to find great fragments and blocks of stone throughout the soil and scattered over the surface. The soil of the broken stone areas is a sand composed of the weathered product of the sandstone mixed with glacial materials. It is usually a red sand of fine to medium texture. On the lower hill slopes the sorting action of the water has in some places produced a more loamy soil, but such spots are small and of no agricultural importance.

Throughout the areas occupied by this type are small patches, from 1 to 5 acres in extent, which are comparatively level and free from stone, and are suitable for farming purposes. Such patches may be seen in cultivation about Onota and Deerton.

Wherever this soil can be cultivated oats, hay, and potatoes can be successfully grown. All root crops do especially well. Timothy grows without much attention, and a considerable amount of timothy hay is cut near Onota.

The greater part of the type is so rough that cultivation is out of the question. The streams have eroded deep valleys and left the hillsides steep and stony. In the vicinity of Deer Lake the rocks rise up as great cliffs, and the country to the north is almost impenetrable.

Notwithstanding the thinness of the soil in many places, nearly all of the Rough stony land was originally covered by a heavy growth of hardwood trees, spruce, pine, and hemlock. The hardwood forests have been extensively cut to furnish wood for the charcoal furnaces.

The Rough stony land will never be utilized to any extent for general farming. The rougher areas admit of but two possibilities—a considerable portion could be converted into pasture, or nearly all could be systematically forested. The land is cheap and the soil is especially adapted to spruce, and it might be a profitable enterprise for the large paper manufacturing companies to reforest this region and provide for the paper industry of the future.

DUNESAND.

The term Dunesand has been applied to the incoherent sand, locally known as "beach sand," deposited along the shore of Lake Superior. Near the water the more recent deposits consist of a clean yellow sand of medium and fine grains, which closely resembles the Dunesand of the Allegan area, on the eastern shore of Lake Michigan. Beyond the reach of wave action there are heaps of the same sand, held only by a sparse growth of coarse grasses. Behind these are narrow ridges parallel to the lake shore and to each other. The ridges are no longer subject to wind or wave action, but have been consolidated by a scattering growth of pine, maple, and birch, and an undergrowth of shrubs, ferns, and grasses. In a few places near the edge of the water the sand gives forth a creaking sound when suddenly compressed, in the same manner as the "musical sands" of the Allegan area.

The largest areas of Dunesand are found at the mouths of some of the streams that empty into Lake Superior. At the mouth of Train River Dunesand covers an area of several square miles, and extends back to the base of the morainal bluff. No dunes of any size are forming and moving inland, as is the case in the southern part of the State, because here there is but little space on which the dunes can collect, and their progress is everywhere checked by clifflike hills. Sand closely resembling the beach sand is found in narrow strips along the top of the Pictured Rocks, at an elevation of nearly 200 feet above the present level of Lake Superior. The peculiar position of this sand and the presence of gravel would seem to indicate that it is of glacial origin.[a]

But few attempts have been made to cultivate the Dunesand, on account of the inability of the sand to retain moisture and plant food. Success could be expected only with such fruit and vegetable crops as thrive on the very lightest sandy soils. The better class of timber has long since been removed, and only small and inferior trees remain. Among the shrubs which make up the undergrowth, the blueberry is the only one of value. A large number of people are employed along the coast during the summer in picking and marketing the berries.

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[a] Foster and Whitney's Report of 1850.

The following mechanical analysis shows the texture of a typical sample of the Dunesand:

Mechanical analysis of Dunesand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12107	1 mile W. of Autrain.	Yellow sand, 0 to 36 inches.	0.1	8.1	47.9	43.2	0.2	0.1	0.8

MIAMI SAND.

The soil of the Miami sand, to a depth of 12 inches, is a slightly loamy sand, interspersed with a small amount of gravel. All grades of sand enter into the composition of the soil, but as a whole it may be said to have a medium texture. The proportion of silt and clay ranges from 4 to 10 per cent, and this, combined with the usually small percentage of organic matter, gives the sand its loamy character. In the subsoil the finer grades of sand usually predominate, the sand, however, being looser and of a lighter color, owing to the lack of organic matter. The gravel content of the subsoil always equals, and in many cases exceeds, that of the soil. The gravel, which ranges from 5 to 15 per cent in both soil and subsoil, is characteristic of the type, and no considerable areas are without it.

A common feature of the Miami sand areas is the presence of ferruginous material within 12 to 18 inches of the surface. It may take the form of loose, finely divided, powdery material, or it may cement the sand grains to form a soft crust. In either case it makes the soil more compact and loamy, and renders it difficult in many places to determine whether the soil should be classed as a sand or a sandy loam. This iron accumulation is due to inadequate drainage, and is greatest where the land is level and heavily forested. It will gradually disappear when the land is cleared and drained.

The Miami sand is the most important soil type of the area, both by reason of the extensive tracts which it occupies and on account of its proximity to the largest towns. It is likely to be found in large or small areas wherever the glacial drift is distributed. Tracts too small to be indicated on the map are found scattered throughout the areas of the other drift types. The material composing the type is of great depth, reaching apparently to the undisturbed rock. There is also every reason to believe that it underlies the loams which have been derived from the glacial débris. The largest and most uniform area of the Miami sand lies between Autrain and Munising, and southward to the southern border of the area. There are also large stretches of the type in the northeastern part of the area.

The topography of the type varies in different parts of the area from gently rolling to rough and hilly, but the former feature is the more prevalent. The extremely rugged tracts are found near Lake Superior, where the morainal material terminates in steep bluffs or cliffs. There are also localities where excessive stream action has cut up the surface of the country until farming is impossible. The more extensive rolling country is well watered by numerous small streams and affords beautiful farm sites.

The variations in productiveness in different parts of the Miami sand areas are due in large part to drainage conditions. On the more level stretches the soil retains moisture well and supports a dense growth of vegetation, chiefly hardwood trees, while on the higher and more completely drained portions there is a sparse forest growth, and pine and hemlock are more frequently found. With the exception of the distinctly marked pine plains, there are no areas so leachy as to allow ordinary crops to suffer, with the invariably heavy rainfall of the region during the growing season. On the other hand, the depressions can nearly all be easily drained and brought under cultivation.

Only a small proportion of the vast area of the Miami sand has been cleared and farmed, but enough has been done to demonstrate that the type is surprisingly fertile for so sandy a soil. The grains and grasses grow to a perfection usually expected only on soils of heavy texture. This productiveness is due to the water supply in the soil being available at all times for the growing crop, by reason of the frequent rains and the water-retaining power of the soil itself. The crops to which most attention has been paid are potatoes and timothy. Timothy hay is the chief money crop, owing to the good local demand. Potatoes come to maturity very quickly and large yields are secured.

The soil is adapted to a wide range of fruits and vegetables and the legumes and root crops do especially well. No experiments have been made with the sugar beet on this type of soil, but judging from experiments on the other sandy soils of the area large beets of a satisfactory sugar content should be grown.

Three sandy tracts, locally known as "pine plains," occur along the southern border of the Munising area. The soil is a loose gray sand to a depth of 5 inches, underlain by a yellow or brown sand. There is little difference in texture between soil and subsoil, both being composed of sand slightly coarser than that of the soil of the remainder of the Miami sand. The percentage of clay and silt is also smaller. Gravel is always present in somewhat larger quantities than in other phases of the Miami sand.

The surface of the pine plains is uniformly rolling, but no streams traverse the areas. The original timber was a growth of rather small pines, but at present only small maple and cherry trees are to be seen. The blueberry grows nearly everywhere on these plains and is very prolific. The cultivation of these pine plains does not appear so hopeless as in some other parts of the State, but they are still of low agricultural value. Owing to the low price of better lands it will be poor economy to attempt at present the cultivation of these inferior lands.

The following table gives the results of mechanical analyses of the fine earth of the Miami sand:

Mechanical analyses of Miami sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12083	2 miles SE. of Wetmore.	Gravelly sand, 0 to 12 inches.	1.7	20.3	26.9	38.3	5.9	5.2	1.3
12085	No. 3-40 of sec. 3, T. 46 N., R. 19 W.	Gray coarse sand, 0 to 10 inches.	2.1	21.1	31.7	30.8	8.9	2.1	3.3
11242	2 miles NW. of Wetmore.	Coarse sand, 0 to 14 inches.	1.9	16.6	23.6	44.9	5.6	3.4	4.2
12084	Subsoil of 12083	Yellow gravelly sand, 12 to 36 inches.	2.8	16.2	25.5	41.8	9.4	1.8	2.2
12086	Subsoil of 12085	Yellow gravelly sand, 10 to 36 inches.	1.6	21.0	32.9	33.5	7.8	.5	2.8
11243	Subsoil of 11242	Sand, 14 to 36 inches	.7	9.2	16.8	33.1	15.7	15.6	8.0

MIAMI SANDY LOAM.

The Miami sandy loam ranks second in extent among the soil types of the area, and parts of it stand first in agricultural possibilities. It is not a soil of uniform texture even in one locality, as it includes the heavier portions of the extremely variable drift deposits, which range from a very loamy sand to a heavy loam. The most common development of the type is a very sandy loam with a depth of 14 to 18 inches, underlain by a loamy sand of fine texture. The soil is naturally of a reddish-brown color, but the top soil is often black with organic matter. Both soil and subsoil contain a small proportion of gravel, the quantity being approximately the same as that in the Miami sand. The gravel, as in the latter type, may be round to subangular in shape, and of almost any mineralogical character. The soil clods when plowed wet only on the heavier phases of the type, as the coarse sand and gravel impart a friable character and cause it to break readily under the plow. Over a large part of the type iron is found in the soil, either as a soft, sandy crust, or more often as a finely divided material, which gives the soil in some places a loamy or compact structure.

The Miami sandy loam may occur in almost any part of the area and in association with any other soil type except the Dunesand. The largest development of the type is found between Onota and Rumely. About Onota the soil is more sandy and hardly distinguishable from the Miami sand, but toward the south the clay content gradually increases until around Rumely the type attains its heaviest texture. Other extensive bodies are located east of Munising on each side of Millers Creek. There are also many areas of the type scattered throughout the sandy soils, some of which are too small to indicate on the soil map.

The surface of the country occupied by the Miami sandy loam is either gently or sharply rolling; the greater part, however, is level enough to be farmed without difficulty. Good drainage is insured everywhere by the slope and elevation of the land and the porous nature of the subsoil.

The Miami sandy loam is a part of the great glacial deposit. Below 3 feet there are usually beds of gravelly sand, which extend to the solid sandstone or limestone underlying the region. Wherever the sandy loam is shallow and the limestone has entered into the composition of the top soil it is classed with the Fort Payne sandy loam. Of the many square miles occupied by this type only a few acres have been cleared and brought under cultivation. The greater part of it is still covered by the original forests of maple, elm, ash, and other hardwoods, with a few hemlocks on the lighter phases. The efforts at cultivation have been almost confined to the land nearest Munising and Autrain, but with the spread of farms from Chatham westward it is certain that the most desirable portions of the type near Rumely will soon be taken up by settlers.

The Miami sandy loam is suited to the production of any crop that may be grown in this region. The soil is heavy enough with the prevailing climatic conditions to produce fair wheat and the shallow-rooted grasses, while root crops do as well as on the more sandy soils. The small areas of this type have been cultivated under such unfavorable conditions that any estimates of crop yields would be worthless, but the results already obtained give promise of profitable farming when the land is well cleared, drained, and cultivated. Timothy grows wherever it is at all favored, and good crops of hay are cut every year. Potatoes do so exceptionally well that they will doubtless continue to be the principle cultivated crop. The sugar beet has not been fully tested on this type of soil, but there is no reason to doubt that it will do as well as on the Fort Payne sandy soil, a soil of similar texture, on which large beets of a high sugar content have been obtained.

The following table shows the results of mechanical analyses of the fine earth of typical samples of the Miami sandy loam:

Mechanical analyses of Miami sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12087	Sec. 32, T. 47 N., R. 18 W.	Sandy loam, 0 to 12 inches.	1.6	11.7	16.0	34.7	16.9	11.7	7.1
12091	Sec. 23, T. 46 N., R. 22 W.	Brown sandy loam, 0 to 18 inches.	1.4	10.7	16.2	35.7	12.4	14.4	9.0
12089	Sec. 19, T. 47 N., R. 17 W.	Sandy loam, 0 to 16 inches.	1.5	12.5	16.0	33.7	12.4	12.8	10.8
12088	Subsoil of 12087	Heavy sand, 12 to 36 inches	1.5	9.2	18.1	39.1	16.7	8.9	5.5
12092	Subsoil of 12091	Sandy loam, 18 to 36 inches	.8	11.2	15.5	38.0	17.9	10.4	5.6
12090	Subsoil of 12089	Brown heavy sand, 16 to 36 inches.	1.3	12.1	16.6	34.9	12.2	13.0	9.6

SUPERIOR CLAY.

The Superior clay is distinguished from all other types of the Munising area in being the only soil with a heavy texture. It consists of a light-colored silty loam with an average depth of 12 inches, underlain by a red silty clay subsoil. The sand constituent of the top soil is of the finer grades, and the subsoil has only the finest sand, which, with the silt, gives the clay a somewhat friable character. When wet the subsoil material puddles, and it does not shrink to any extent in drying. Bricks of good quality are made of this clay.

The Superior clay occupies a small area about Hallston, 3 miles from Munising, on the line of the Munising Railway. Portions of it are rough and unfit for cultivation. The area is cut up by the deep channels of numerous small tributaries of Anna River, and tracts of only a few acres are uneroded. The clay owes its origin to a deposition of glacial material, but why a local deposit of clay should occur within such a vast area of sandy soils can not be determined.

The hilly topography of the Superior clay impairs its value for general farming, but it is well adapted to pasture and dairy farming, and its proximity to Munising adds to its value for that purpose, At present hay is the only product obtained from the soil. No care is taken of the grasses, but timothy makes a thick, heavy growth wherever the land is cleared.

The following mechanical analyses show the texture of the soil and subsoil of the Superior clay:

Mechanical analyses of Superior clay.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
12101	1 mile NE. of Hallston.	Silty loam, 0 to 14 inches.	0.2	1.8	3.1	5.8	7.8	47.1	34.2
12099	½ mile S. of Hallston.	Silty loam, 0 to 10 inches.	.0	.9	1.6	4.8	5.2	49.6	37.7
12100	Subsoil of 12099	Heavy silty clay, 10 to 36 inches.	.0	.9	1.5	5.3	3.8	51.2	37.5
12102	Subsoil of 12101	Heavy silty clay, 14 to 36 inches.	.0	1.1	1.1	3.4	3.7	51.7	38.9

FORT PAYNE SANDY LOAM.

The Fort Payne sandy loam is the only type of soil derived by weathering from the calcareous rocks which underlie a large part of the region. The soil, to an average depth of 6 inches, consists of a brown and very sandy loam, usually mixed with gravel and small fragments of stone. The subsoil is a sandy loam of lighter color, filled with rock fragments that have resisted weathering, and passing finally into the partly decomposed rock. The depth of the arable soil is variable; in places it attains a depth of 5 or 6 feet, while in others the unweathered rock comes to the surface. Over a part of the State farm at Chatham the soil is only a few inches deep, and blasting of the rock is necessary in the construction of drainage ditches. The soil is very productive, and maintains its productiveness under continued cultivation. Humus is perhaps better retained by the Fort Payne sandy loam than by any other type of the area.

Only two tracts of this soil were found in the Munising area, but the type covers a wide scope of country to the south of this area. The larger tract, which is located about Chatham, has a triangular shape, spreading to a width of 6 miles along the southern border. The other tract is a few miles east of Shingleton, but the type here is not so well developed as in the area around Chatham.

The topography, being more or less hilly, does not differ from that of the Miami sandy loam. The soil is usually thinner on the hillsides than on the more level land.

The Fort Payne sandy loam is the result of the weathering of the sandy dolomite which is characteristic of the Calciferous group of the Silurian. The rock is broken up by the removal of the calcium carbonate by carbonated waters, leaving the sand and other difficultly soluble constituents of the soil. In some places the glacial drift has entered to some extent into the composition of this soil.

The agricultural value of the Fort Payne sandy loam has been demonstrated at the State Experiment Farm at Chatham, where various crops have been grown for four years with the view of determining what crops are adapted to this soil and what yields may reasonably be expected. The results have shown that for general farming wheat, oats, rye, and barley may be grown with good yields. Peas and all legumes adapted to the climate make a wonderful growth. Potatoes grown on this soil are of a superior quality, being large and smooth, and yielding about 200 bushels per acre. Vegetables of all kinds, especially the root crops, mature very early and make good yields. The experiments with the sugar beet are described in another chapter.

The following table shows the texture of typical samples of the fine earth of the Fort Payne sandy loam:

Mechanical analyses of Fort Payne sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12097	Chatham	Dark fine sandy loam, 0 to 6 inches.	0.2	3.3	7.3	34.9	27.0	20.9	6.2
11244	3½ miles W. of Munising.	Sandy loam, 0 to 18 inches.	1.2	10.7	17.9	35.3	15.3	11.8	8.1
12095	2 miles E. of Chatham.	Brown sandy loam, 0 to 12 inches.	3.5	3.4	8.3	37.0	23.5	14.6	9.2
11245	Subsoil of 11244	Loamy fine sand, 18 to 36 inches.	.0	.0	Tr.	47.0	34.2	14.7	3.9
12098	Subsoil of 12097	Sandy loam, 6 to 36 inches.	1.3	4.3	7.6	38.5	24.0	16.1	8.1
12096	Subsoil of 12095	Sandy loam, 12 to 36 inches.	3.4	20.5	7.2	21.7	21.8	15.1	10.8

MUCK.

There are numerous depressions throughout the area surveyed where the lack of natural drainage has permitted the accumulation of vegetable matter. These areas are locally called "cedar swamps," as they are everywhere characterized by a growth of white cedar. They are usually confined to narrow strips along the stream courses, but in a few instances they occupy considerable areas between two streams. The material which has filled these swamps is composed of the partially decayed remains of plants, leaves, and mosses which have grown in the immediate vicinity. The value of the soil thus formed is determined by the extent of the decomposition, and this varies frequently, even in the same swamp. Over a large part of these areas, however, the soil mass has reached the condition of Muck, and is suited to agriculture. Where decay has not advanced to this stage, the plant remains form a wet, spongy mass, which is called "bog" by the lumbermen to distinguish it from the more compact Muck. It has not been found practicable to map these differences, as the bog areas are small and the almost impenetrable character of the swamp renders the work well-nigh impossible. It is also unnecessary, because it is well known that the more peaty materials undergo rapid decomposition when exposed to the air, and it is not likely that any considerable areas will be found worthless when the swamps have been drained. The Muck varies in depth from a few inches to more than 10 feet, and in some places it is underlain by a thin bed of impure marl.

The Muck areas are invariably covered by a heavy growth of water-loving trees, including the white cedar, ash, maple, and tamarack. The tamarack is rarely found in the southwestern part of the area. It is more common in the swamp areas bordering the northward-flowing streams. It is claimed by some that celery can not be successfully grown on areas that have supported tamarack. This may be due to the greater acidity of such areas, but, if so, the acid condition should disappear when the soil is thoroughly drained.

Small patches of Muck sometimes occur in cultivated fields, but no attempt has been made to cultivate the Muck as a type with crops adapted to it, except at the experiment farm at Chatham, where good celery, cabbage, and turnips have been grown. No doubt when the country is cleared and drained the Muck will be one of the most desirable soils. Onions, cabbage, radishes, and potatoes could be produced on nearly all the areas, while celery and peppermint are possibilities over a large portion of the Muck.

MARSH.

The small Marsh in the southeastern part of the Munising area is not in itself of any agricultural importance, but as it is representative of the larger tracts of Marsh farther east, it presents the most important soil problem of the upper peninsula of Michigan. The soil is a black mass of partially decayed vegetable matter, having an average depth of about 2 feet, but in some places reaching a depth of 6 feet or more. This material consists of plant remains evidently washed in from higher ground, as layers of well-rotted Muck alternate with layers of less decomposed peaty accumulations.

The top soil is everywhere sufficiently decomposed to be of agricultural value. Below this mucky soil is a more peaty, stringy mass composed of the remains of plants and mosses mixed with a fine sand which seems to increase in quantity with depth.

The Marsh is confined to one locality in the area, occupying a narrow strip within a swamp and bordering a small stream. The soil itself is not greatly different from that of the neighboring swamps, but the heavy timber growth of the latter is entirely lacking. Coarse grasses and moss form the vegetation of the water-soaked soil. The treeless condition of the areas may be accounted for by the imperfect drainage. Water stands everywhere within a few inches of the surface, and over a large part of the Marsh the surface is partially covered with standing water. In seasons of heavy rainfall all of it is covered with water for several weeks at a time.

Only one attempt has been made to cultivate this Marsh, and it was not successful owing to the lack of drainage. Small surface ditches were dug, but they were not sufficient to remove the excess of water in the soil. The adequate drainage of large areas of this type of Marsh land can only be accomplished by corporations or individuals able to invest large sums of money in general drainage systems. The possibility of draining these areas is demonstrated by the local effect of ditches constructed along the railroads, and the elevation and slope of the land should render feasible the establishment of general drainage channels. Capitalists are now ready to take up this reclamation work whenever they are assured that the soil itself would justify the expenditures. We can judge the capabilities of this soil only by the character of the vegetation already taking hold under the present adverse conditions. The grasses growing on the wet land are of some feeding value and are sometimes cut for hay. It is certain that when these areas are drained the proportion of valuable forage grasses will greatly increase and the areas will be converted into good pasture lands. Better drained areas along the railroad support a fine growth of timothy, indicating that the soil is adapted to the cultivated grasses.

The value of the Marsh for purposes of general farming can only be determined by actual experiment. The character of the soil would indicate that when drained the crops that flourish on a muck soil should do well.

ADAPTATION OF SOILS AND CLIMATE TO SUGAR BEETS.

Sugar beets have been grown only in an experimental way in Alger County, but the results, in connection with those obtained in the other counties of the upper peninsula, indicate that this may be a part of one of the best sugar-producing sections of Michigan. As late as 1896 maps of the supposed sugar-beet belt included only the southern part of the State, with Lansing as the most northern point, and it was thought that the beet had reached the northern limit of production. This supposition was based on the belief that beet culture would not be a success outside of a climatic belt extending 100 miles on each side of the isothermal line of 70° for the months of June, July, and August.

Later investigations show that the economical production of beets is not confined to these limits, and that other conditions besides temperature influence the quality of the beet. In a bulletin issued by the U. S. Department of Agriculture in 1899, Dr. H. W. Wiley sums up the facts, as follows:

> North of the limit of the belt, however, the extension of the culture of the beet can be pushed just as far as the climate will permit the ripening of the crop and the harvesting and the care of the crop before the freezing of winter sets in. Our experience in this country has shown that the farther north, other things being equal, beet culture is practiced the better the quality of the beets produced. This is due to the fact that by reason of the longer days which are secured by going farther north the activity of the chlorophyll cells of the beet leaves, in which, under the influence of light and heat, the sugar is elaborated, is increased and extended, so that more sugar can be made for a given leaf surface than farther south. In addition the lower temperature seems to favor the elaboration and accumulation of the sugar.

In Bulletin 64, Bureau of Chemistry, this statement is made:

> It is evident that the elements of sunlight, which are active in promoting the action of the chlorophyll cells in the formation of sugar, do not depend upon the direct rays of the sun. The diffused light coming through the clouds is apparently quite as effective as the direct sunlight.

A comparison of the amount of time in which the sun is above the horizon in different parts of the State, during the six months from April 15 to October 15, shows that Houghton, slightly above latitude 47°, receives 56.33 hours more of sunshine than Grand Rapids, in latitude 43°, and 69.13 hours more than Coldwater and Adrian, in latitude 42°. The favorable effect of the different climatic conditions of the northern latitudes is proved beyond doubt by the experiments made by the State Agricultural College Experiment Station.[a] From 1897 to 1902, inclusive, samples of beets were obtained for analysis from 74 out of the 83 counties of the State, the total number of samples being 1,114. The results show a range in the sugar content from 13.4 per cent in the samples from the southern tier of counties to 15.4 per cent for the beets grown in the latitude of Alger County.[b] With few irregularities there was a gradual increase in the richness of the beets toward the north. The beets grown at the experiment station in Alger County during several years have varied in sugar content from

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[a] Special Bulletin No. 18, Michigan State Agricultural College.

[b] Bulletin No. 207, Michigan Experiment Station.

14.2 per cent to 17.6 per cent. A safe average from year to year could perhaps be placed between 15 and 16 per cent, with a purity coefficient of about 84.

The fact that the ground never freezes to any extent in the Munising area suggested the experiment of leaving the beets in the ground during the winter, to determine whether they could be kept in this manner and what the effect would be on the composition. The results for the winter of 1903–4 show that the beets have been perfectly preserved, and that there has been neither loss of weight nor decrease in the amount of sugar. The one experiment can hardly be said to show the wisdom of this plan, but if such a method should prove to be practicable, it will have great influence on the future development of the beet industry in the upper peninsula, as the disadvantages of a short season for harvesting and manufacturing will be eliminated.

Even if this plan is not practicable, the beet will no doubt be extensively grown on the more loamy soils of the upper peninsula, and the profits derived from the industry will be as large here as in the southern part of the State. In Alger County the crop will probably be confined to the Miami sandy loam and the Fort Payne sandy loam, as it has been the history of the industry elsewhere that the tonnage is greater and the quality better on the loamy or heavy soils.

AGRICULTURAL CONDITIONS.

As already noted, the Munising area is still new in an agricultural sense, and the small population engaged in farming is yet undergoing the hardships that fall to the lot of pioneers. As a rule only the bare necessities of life have been accumulated about the farms. The dwellings and barns are hastily constructed log buildings. The fields are mostly irregular, stump-covered patches of cleared land inclosed by brush fences. These conditions will be rapidly improved when the farmers produce a surplus above the needs of the family. All the settlers have had to make a start in the wilderness without capital, and, many of them being foreigners, have been handicapped by an ignorance of the country and its language. With these facts in view, it can be said that the progress of the community has been exceptionally rapid, and much can justly be expected of it along agricultural lines in the future.

With only a few exceptions the farmers own the land which they cultivate. Many are still in debt for their land, but in most cases it was contracted for under such easy conditions that the payments will be made without difficulty. The average size of farms, as given by the Twelfth Census, is 117 acres, but the average amount of cleared land on each farm is less than 20 acres. The greater part of the land has not been divided into farms, but is owned or controlled by large mining or lumbering companies. It is not the intention of these corporations to hold this land indefinitely, but to dispose of it as soon as the more valuable timber has been removed. To this end they are making every effort to attract immigration and offer land under easy conditions of payment. The largest owner among these corporations holds more than one-half the arable land of the area.

The price of land varies with location, quantity and kind of timber, and state of improvement. Few, if any, homesteads of any value are now to be had. Land values are rapidly increasing, and especially is this the case with the timbered lands. Cleared and improved farms are worth from $20 an acre up. The average price of good farming land where the better class of timber has been removed is about $8 an an acre.

The farmers have not found it necessary to employ much labor in cultivating their small farms. It is only in haying time that the average farmer hires help. The available laborers are the spare hands from the lumber camps, and are chiefly of Swedish or Finnish nationality. Wages are high, owing to the demand for laborers in the various industries of the region. The laborers are hardy and accustomed to hard work. The price of labor for short periods is from $1.25 to $2 a day.

The largest and most valuable crop of the area is potatoes, and about 30,000 bushels were produced in the present year. Of the other crops not enough is grown to supply the needs of the area. Hay ranks next to potatoes in value. Timothy is a sure crop and is grown to the exclusion of other grasses wherever the land is cleared, much of the hay produced being of no expense to the farmer aside from the cost of cutting and storing. A considerable acreage is devoted to oats, and the average yield is about 32 bushels per acre. Wheat is not widely grown, but the yields are fairly good. No corn is produced, as the seasons are too short and the nights too cool for it to mature. A wide variety of fruits and vegetables may be grown, and the farmers can not be too earnestly urged to take up the cultivation of these profitable crops. The peach tree invariably winter-kills, but other fruit trees do well and the fruit is of excellent quality. The difference in the time of ripening puts many kinds of fruit grown here out of competition with that of other localities. The cherry, for instance, ripens in the fall, and should bring a fancy price on the market. Among the small fruits strawberries make heavy yields, and the fruit is large and of fine flavor. Gooseberries, raspberries, blackberries, and blueberries grow wild, and large quantities, especially of the blueberries, are picked and shipped to the Chicago market. The price ranges from $1 to $2 a half-bushel crate.

The area is well provided with railroads. The Duluth, South Shore and Atlantic Railroad and the Munising Railway traverse the area from east to west and furnish rapid communication with Chicago, Milwaukee, Grand Rapids, and the copper and iron mining regions. Munising has an excellent harbor, and while the shipping by water is very light at present, it will doubtless be of much importance in the future.

The most urgent need of the farming communities is good country roads. The few roads that traverse the area are, as a rule, not well located and are seldom in good condition. Main roads were once built through the area, but were not planned to suit present needs, and have fallen into disuse. Many of the farmers have the railroad as their only means of transportation. The roads cut by the lumbermen are generally useless to the public, as they are mere clearings through the woods, designed for moving logs over the heavy snows. No great prosperity can come to the farmers until better means of communication are established between different parts of the region. Under present conditions the farmers can not supply the local markets with their products. It is to be hoped that the county will rapidly push the work of constructing good roads.

There are few regions where the farmers have less competition in the sale of their produce. Besides the local markets, which have never been supplied, the proximity of the area to the iron and copper mining regions, with a population of more than 100,000 engaged in other pursuits than agriculture, insures a ready market for all farm produce that can be furnished by this area. The products that could be most profitably grown to supply this market are vegetables, fruits, and dairy products. At present these commodities are reshipped from the Chicago markets to the mining regions.

SOIL SURVEY OF THE SAGINAW AREA, MICHIGAN.

By W. E. McLENDON and M. EARL CARR.

LOCATION AND BOUNDARIES OF THE AREA.

The Saginaw area includes parts of Bay, Huron, Saginaw, and Tuscola counties, and comprises 984 square miles. It lies almost wholly within what is known as the Saginaw Valley, and is situated between 43° 20′ and 43° 45′ north latitude and 83° 10′ and 84° 10′ west longitude. It is bounded on the north by Saginaw Bay and township 16 N., in Bay and Huron counties; on the east by Grant

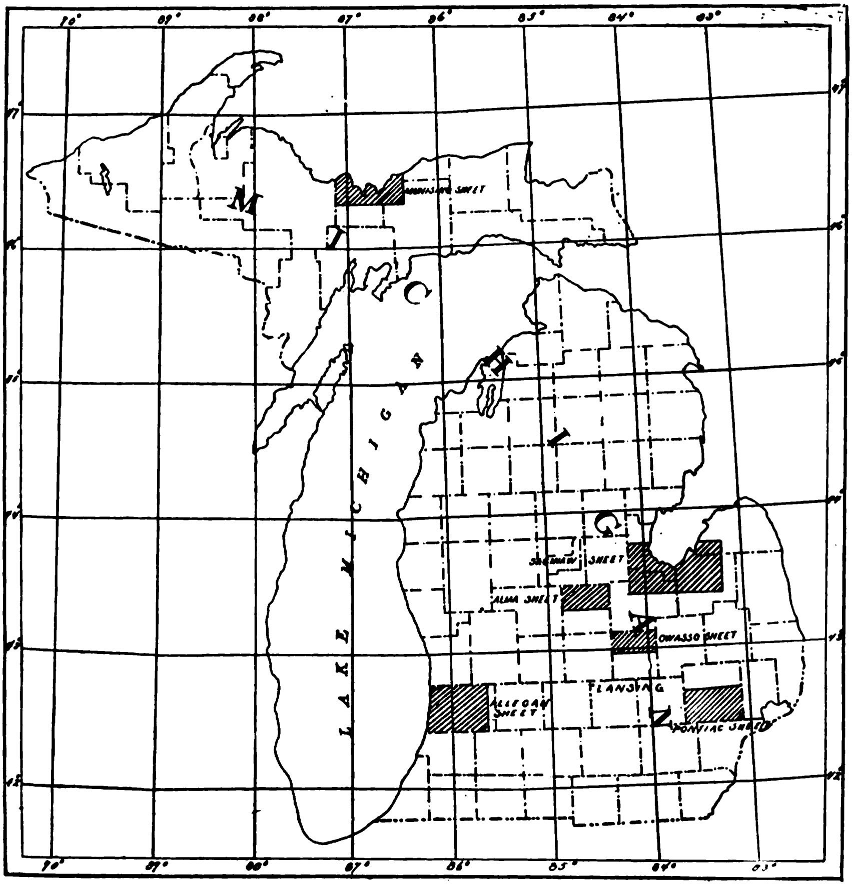

FIG. 25.—Sketch map showing location of the Saginaw area, Michigan.

Township, of Huron County, and the eastern tier of townships of Tuscola County in R. 11 E.; on the south by township 11 N. in Saginaw and Tuscola counties, except for a distance of 12 miles from the eastern edge, where an extra tier of sections is included in the survey, and on the west by Midland County and Richland Township of Saginaw County in R. 2 E.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

There were a few French trappers living among the Indians as early as 1811, but no white settlers occupied the valley until the Government erected and garrisoned Fort Saginaw in 1822. The establishment of a trading post at Fort Saginaw by the American Fur Company in 1824 brought a few more whites to the wilderness, and in less than three years settlers began to flock to the valley with the intention of making it their future home. By 1836 nearly all the land had been filed upon, either for actual occupation or for speculative purposes.

The whole area was heavily forested, and it was natural that the settlers should first direct their attention and energies to the lumbering industry. In fact, it was for a long time thought that the lands were good for little else than the timber they supported. This industry was carried forward with success until the early seventies, when it began to decline on account of the exhaustion of the supply. With the lumbermen, of course, came sawmills and large numbers of operatives. Many of these mills were located at Saginaw and Bay City, and it was about these two places that the various industries of the valley were built up.

The white settlers did very little farming until the decline of the lumbering industry. In the meantime, however, it had been fully demonstrated that the soils, when drained, were peculiarly adapted to farming, and the agricultural development of the valley began in earnest. In a period of thirty years the whole region has been transformed from a virtual wilderness into one of the best-developed and most prosperous farming sections of Michigan.

To the German immigration, which began as early as 1845, is due a great deal of the credit for the earlier agricultural development of the area, and the German element forms an important part of the present agricultural population. For the last fifteen years there has also been an influx of Poles to the area. Many of these immigrants have bought farms, but the larger number have joined the laboring classes, both in the cities and in the rural districts.

Saginaw was founded in 1822 and Bay City in 1836, but they were little more than names until after 1850. Saginaw Township, comprising a dozen or more of the present counties, was organized in

1831. In 1835 Saginaw County was organized under the Michigan Territorial government, and Tuscola in 1850 and Bay in 1857 under the State government.

The first railroad in the area was begun from Saginaw in 1859, extended to Bay City in 1867, and connected with lines to the south in 1872, giving the first railroad outlets to other parts of the country. Nearly all of the earlier transportation was by water.

CLIMATE.

The summers in this part of Michigan are short and pleasant and the winters long and severe. July is the hottest and February the coldest month of the year. The proximity of the Great Lakes in general and Saginaw Bay in particular modifies the climate to a considerable extent, and it is not marked by sudden changes and violent extremes, although the range in temperature between the extremes of summer and winter is great. This equable character of climate, the dependable protection of the snows, and the freedom from erratic frosts are highly favorable to agricultural pursuits.

The data given in the appended tables are taken from Weather Bureau records of the stations at Saginaw and Vassar. Vassar is outside of the area, but is sufficiently near to be fairly representative of the higher portions of the area farther back from the bay front. It will be noticed that February is nearly 6 degrees colder at Vassar than at Saginaw. On the other hand, the annual rainfall is nearly 3 inches heavier at Saginaw.

At Saginaw the last killing frost in spring ranges from April 16 to May 23, and the first in fall from September 14 to October 14. The records of frost occurrence at Vassar are too fragmentary to show much. On the low, wet areas frost may be expected from one to two weeks earlier than on the higher, better drained lands. Occasionally the corn, bean, and cucumber crops are cut short by early fall frosts.

Normal monthly and annual temperature and precipitation.

Month.	Saginaw West Side.		Vassar.	
	Temperature.	Precipitation.	Temperature.	Precipitation.
	° F.	*Inches.*	*° F.*	*Inches.*
January	23.1	2.65	23.3	1.76
February	20.8	2.28	15.0	1.79
March	31.6	3.08	28.7	3.49
April	46.2	1.95	45.8	1.45
May	59.0	3.11	56.4	3.11
June	67.9	2.87	65.1	2.53
July	72.8	3.69	71.0	4.48
August	69.8	3.21	68.6	3.04
September	61.7	2.95	61.6	2.07
October	50.4	2.94	....	3.16
November	37.7	2.53	38.2	2.22
December	26.9	1.90	26.1	1.34
Year	47.3	33.16	....	30.44

Dates of first and last killing frosts.

Year.	Saginaw.		Year.	Saginaw.	
	Last in spring.	First in fall.		Last in spring.	First in fall.
1896		Sept. 28	1901		Sept. 19
1897	May 23	Sept. 20	1902	May 11	Oct. 10
1898	May 6	Oct. 14	1903		Sept. 19
1899	Apr. 16	Sept. 14	Average	May 6	Sept. 28
1900	May 5	Oct. 10			

PHYSIOGRAPHY AND GEOLOGY.

The surface features of the Saginaw area fall into two main divisions—the lowlands of level or slightly rolling old glacial lake beds and the upland ridges of rolling and hilly glacial moraines.

The lacustrine lowlands occupy the whole northern, western, and central parts of the area, besides an intermorainic area between the two bodies of upland in the southeastern part, and make up about 935 square miles, or about 95 per cent of the area. As already stated, the topography of these lowlands is nearly level to slightly rolling or undulating. In elevation they vary from the level of Saginaw Bay, 580 feet above sea level, along Saginaw River and the shore of the bay, to about 700 feet at the base of the upland moraines. However, the intermorainic area is slightly higher, and rises gradually toward the southeastern corner of the survey. Numerous ridges or old beach lines are scattered throughout the lowlands. Those west of the Saginaw River extend in a general northwest-southeast direction, and nearly parallel the present bay front, while east of Saginaw River their trend is in a northeast-southwest direction, also paralleling in a general way the east front of the bay. In the western half of the survey these beaches form prominent ridges of medium to fine sand, with scarcely a trace of gravel, except in the lower depths. Some of these ridges rise to a height of from 10 to 30 feet above the adjoining level lands. In the eastern half of the survey the beach lines are not so prominently developed and are distinguished from the surrounding country by low swells or ridges, consisting of medium gravelly sand and sandy loam. Along the Saginaw River, between Saginaw and Bay City, is a considerable area so low lying as to be covered partially by water and only to a limited extent adapted to agricultural purposes. Parts of Beaver, Kawkawlin, Williams, Tittabawassee, and Thomastown townships, in the western part of the area, are quite rolling in the vicinity of some of the old beach lines, and as a whole are somewhat higher than the area farther east.

The intermorainic area previously referred to differs from the other lowlands in that it contains no heavy soils, but consists of medium to coarse sands and stony sandy loams.

The morainic uplands in the southeastern part of the area occur in two bodies, separated, as before stated, by a body of lowlands. The more important of these two upland areas occurs as a ridge varying from 1 to 3 miles in width. It enters the area at Gagetown, on the eastern border, and extends in a southwesterly direction, passing just to the north and west of Caro and leaving the area about 18 miles from the southeastern corner. The other upland area occupies the extreme southeastern corner of the survey. The physiography of these uplands is characteristically that of a deposit left by a glacier during a halt of some duration.

The larger body, or ridge, at its greatest elevation rises to about 800 feet above sea level, or about 100 feet above the adjoining lowlands. Its surface is very rolling, but rarely so much so as to be a serious hindrance to cultivation. Some parts of the upland area occupying the extreme southeastern corner of the survey reach a height of about 900 feet above tide, and the topography is there more broken than in the strip farther west, yet a greater proportion of it is under cultivation.

The main drainage system of the area is the Saginaw River and its tributaries. This river has little fall, and the country on both sides is so level that artificial drainage is necessary over wide areas. The waters of the southwestern part of the area reach the Saginaw River through the Tittabawassee River, which flows in a southeasterly direction across Tittabawassee, Thomastown, and Saginaw townships, joining the Saginaw River just south of the area. In the southeastern part of the area the Cass River flows southwest across Ellington, Almer, Indian Fields, and Juniata townships, passing out of the area northeast of Vassar and emptying into the Saginaw River. Along the bay front are several small streams, the more important being the Sebewaing, Quanicassee, and Kawkawlin rivers.

The structural geology of the area is of no direct importance from an agricultural standpoint, as the underlying rocks are buried so deeply by deposits of glacial material that they have no influence upon the soils. These rocks all belong to the Carboniferous system. The Coal Measures are found everywhere in the area except along the eastern edge. Economically these deposits are of vast importance. At a depth of from 80 to 150 feet coal is found of sufficient thickness to mine profitably, giving an excellent fuel at a moderate price. Limestone from the coal mines furnishes excellent building stone, cement rock, road metal, and lime for clarifying purposes in beet-sugar manufacture and for various other cases. Salt is also found at a depth varying from 700 or 800 feet at Saginaw to 1,050 feet at Bay City.

The surface geology consists entirely of glacial material, either as a land deposit, as with the upland ridges, or as reworked material deposited in an old lake formed about the southern extremity of the ice sheet. The lake deposits, or lowlands, were subsequently modified to some extent by wave action on the retreat of the old lake to the present position occupied by Lake Huron. These glacial deposits range from 50 to 100 feet or more in thickness, and carry only a small percentage of gravel, except east of Cass River, where there are a number of bowlders strewn over the surface, and occurring to a less extent in the soil mass. The gravel is chiefly granitic.

SOILS.

Seventeen different types of soil were recognized in the area. The name and actual and relative extent of each of these are given in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Clyde loam	242,496	38.5	Miami gravelly sand	14,176	2.2
Clyde sandy loam	84,608	13.4	Saginaw sandy loam	12,992	2.1
Miami sand	52,000	8.3	Clyde gravelly sand	10,496	1.6
Clyde fine sandy loam	39,104	6.2	Miami fine sandy loam	10,048	1.6
Miami fine sand	36,608	5.8	Clyde stony sandy loam	8,000	1.3
Muck	30,784	4.9	Clyde silt loam	3,904	.6
Clyde clay	26,560	4.2	Swamp	1,344	.2
Miami clay loam	26,240	4.2	Total	630,016	
Meadow	16,000	2.5			
Clyde sand	14,656	2.3			

MIAMI SAND.

The Miami sand is a loose brown sand of medium to coarse texture, 6 to 9 inches deep, underlain to a depth of 3 feet or more by a similar sand of a reddish-brown or yellow color. The soil is generally deficient in organic matter, but the small amount present renders it loamy and more retentive of moisture. In the native state the soil is practically devoid of organic matter except in the first inch or so.

Owing to a wide range of drainage conditions, there is considerable variation in the color of both soil and subsoil. In the depressions patches of Muck are frequently found, and from these to the higher areas there is a gradation of color from dark to light. The sand for the entire depth of 3 feet may be of a light-gray color, and again only a few inches of the surface may be a light gray, the soil soon changing to yellow or brown. More rarely the surface may be brown and the subsoil white. All these variations may occur within very limited areas, and often give a spotted appearance to a newly plowed field. The ridges, hillocks, and more broken areas in general follow the type description.

The Miami sand is the most extensive soil type east of Cass River. Smaller areas border the river on the west. Between the moraine hills lying between Caro and the bay occur numerous beach formations, which are occupied partly by this type and partly by the Miami gravelly sand, the latter being found principally on the larger ridges.

The origin of the type is somewhat varied. West of Caro it is mostly material deposited along the beaches of the glacial lakes, while to the east and south of Caro it has originated partly from material brought down by glacial streams and deposited in the old lake once covering that section, and partly from glacial deposits without the intervention of lacustrine agencies.

The topography and drainage features of the type vary in areas of different origin. Where it occupies portions of old beach lines the surface consists of low, gently rolling ridges, while in the larger areas it varies from nearly level to a ridgy, hillocky, and broken topography. A few areas in the southeastern corner of the survey have the topography typical of glacial uplands. The more broken and rolling areas are generally well drained, while the level areas usually have poor drainage, and often approach the condition of true swamp.

The type is still largely in an unimproved state. Some of it is used for summer pasturage, but this is of a very poor character. The larger areas were originally heavily forested with pine, but since this has been removed swamp poplar (quaking aspen) has become the principal tree growth, and is used to a limited extent for fuel. The beaches immediately along the bay front support a scanty growth of oak, and farther inland there is a mixture of oak, maple, and beech.

The cultivated areas are devoted to the general farm crops, the yields being usually light and uncertain. Some attention is also given to dairying and to special crops, such as sugar beets, beans, potatoes, cucumbers, and fruits. This soil is unsuitable for beet culture, but the other special crops mentioned give good results when properly fertilized and cared for. Among the fruits apples, pears, cherries, grapes, and raspberries do well. This soil should be used for truck and fruit crops rather than for general farm purposes. Certain undesirable areas should be drained and reforested with pine.

Mechanical analyses of the fine earth of a representative sample of this soil are given in the following table:

Mechanical analyses of Miami sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11781	NE. cor. sec. 22, T. 12 N., R 9 E.	Medium to coarse sand, 0 to 6 inches.	1.8	26.0	25.9	33.0	3.3	5.4	4.6
11782	Subsoil of 11781	Medium to coarse sand, 6 to 36 inches.	2.4	37.6	27.3	24.2	2.5	2.4	2.8

MIAMI GRAVELLY SAND.

The Miami gravelly sand consists of a brown gravelly sand, of medium to coarse texture, 9 to 12 inches deep, grading through a lighter brown gravelly sand into a mixture of coarse sand and fine gravel at a depth of about 3 feet below the surface. In some places the underlying gravel comes within a few inches of the surface.

This type of soil is closely associated with the Miami sand, and except for the gravel it contains might be classed as the Miami sand. It also resembles in many respects the Clyde gravelly sand, the latter type, however, being of more value for agricultural purposes.

The Miami gravelly sand owes its origin to material deposited by wave or stream action. It occupies mainly the larger of the ridges lying between Caro and the bay and represents old beach lines. It may occur also in patches bordering or within areas of the Miami sand. Its usually rolling or ridgy topography insures good drainage

The type produces about the same crops as are grown upon the Miami sand, but the yields are somewhat better.

The following table gives the results of mechanical analyses of a typical sample of this soil:

Mechanical analyses of Miami gravelly sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11779	N. cen. SE. ¼ sec. 2, T. 12 N., R. 9 E.	Medium to coarse sand, 0 to 8 inches.	1.5	25.1	36.2	25.7	2.7	3.7	4.9
11780	Subsoil of 11779	Coarse sand, 8 to 36 inches	1.7	23.5	36.3	27.0	4.0	3.2	3.8

CLYDE SAND.

The Clyde sand is an intermediate type between the Miami sand and Miami fine sand on the one hand, and true Muck on the other, and its real character is most nearly expressed in the term "mucky sand." The soil is a dark-gray to black medium-textured sand 8 to 14 inches deep, underlain by an incoherent white sand of medium or coarse texture to a depth of 2½ feet, where a heavy silty clay is usually encountered. Occasionally the depth to clay is more than 2½ feet, and where slightly better conditions of drainage are found the subsoil consists of a light-yellow sand. A small proportion of fine gravel is found in parts of the type. The large amount of organic matter present in the soil renders it loamy and mellow and causes it to be quite retentive of moisture.

The type is of lake or stream origin and is still in process of formation along the bay front. Unlike the Miami fine sand, with which it is often associated, it has not been modified to any extent by wind action. It also differs from the fine sand in topography, occupying level areas. It is naturally poorly drained, which accounts for its mucky condition.

The larger areas occur in Bangor, Hampton, Merritt, Gilford, Wisner, Akron, and Sebewaing townships, and smaller ones are found throughout the survey, generally associated with areas of the Miami sand, the Miami fine sand, or Muck. Under better drainage conditions the greater part of the areas mapped as Meadow and Swamp along the bay front would become Clyde sand.

Where artificial drainage has been resorted to, the Clyde sand is one of the most desirable soils of the area for truck farming, and under careful management nearly all of the general crops can be grown with satisfactory results. To maintain the productivity of this soil, it is necessary to keep it well supplied with organic matter, or else it reverts to a physical condition more nearly like that of the other sandy soils of the area. With level topography and a comparatively shallow clay subsoil, this type is, however, more susceptible of lasting improvement than either of the other sandy types.

The areas shown in the eastern part of the area are used largely for general farming, and in a small way also for dairying, while those occurring in the western part of the survey are used for a diversity of crops. Besides corn, oats, wheat, timothy, clover, and buckwheat, of the general farming crops, beets and chicory are extensively grown. In fact, the Saginaw sandy loam and Clyde sand are the principal chicory soils of the area. Corn will yield on an average from 20 to 35 bushels per acre, wheat from 15 to 30 bushels, beets from 10 to 15 tons, chicory about 10 tons, and the other crops proportionately well. On the western half of the areas a large acreage is devoted to trucking. Cabbage, cauliflower, tomatoes, potatoes, onions, cucumbers, and beans are the principal truck crops.

Areas lying along the shore of the bay are used only for summer pasturage.

The following table gives the results of mechanical analyses of typical samples of the Clyde sand:

Mechanical analyses of Clyde sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11775	SE. cor. of SW. ¼ sec. 32, T. 14 N., R. 6 E.	Black medium sand, 0 to 9 inches.	0.2	2.8	26.7	58.8	4.8	2.8	3.9
11777	W. side of SW. ¼ sec. 22, T. 14 N., R. 6 E.	Black medium sand, 0 to 14 inches.	1.2	7.2	23.6	48.7	6.7	7.3	5.1
11776	Subsoil of 11775......	Gray medium sand, 9 to 36 inches.	.2	4.8	27.4	61.7	3.6	.5	1.5
11778	Subsoil of 11777......	Medium sand, 14 to 30 inches.	1.0	7.1	24.4	57.3	4.9	1.9	3.0

MIAMI FINE SAND.

The Miami fine sand is a medium to fine incoherent brown or gray sand from 6 to 9 inches deep, underlain by a similar textured sand of a reddish-brown color, generally changing to a lighter color in the lower depths. The sand ranges from 3 to 30 feet in depth, and is almost entirely devoid of gravel, except just above the clay line, where a streak of gravelly medium to coarse sand is usually found, similar to the material composing the Miami gravelly sand.

Nearly all of the larger areas of this type are poorly drained, and in the depressions the soil grades toward Muck or the Clyde sand. Except in such areas the type carries a very small proportion of organic matter.

The surface features range from slightly undulating and hillocky in some of the larger areas to ridges in the old beach lines, from 5 to 25 feet above the adjoining lowlands. The ridges are fairly well drained, while the intervening depressions and level areas usually have poor drainage.

This soil is entirely of lake origin, being derived either from beach deposits subsequently drifted into ridges and hillocks by the winds, or from materials forming the deltas of some of the streams flowing into the glacial lakes already referred to as covering at one time the greater part of the territory included in the survey. These delta areas, too, have been modified to some extent by wind and wave action. A considerable area at the mouth of the Kawkawlin River and a larger area bordering the Cass River in Juniata Township are believed to be delta deposits, while the remaining areas are mainly old beach lines.

The largest area mapped is south of Watrousville, in Juniata Township, and many others are found in the vicinity of Bay City and west of Saginaw and Tittabawassee rivers. One prominent ridge extends from Bay City through Kawkawlin and out of the area in section 3 of Kawkawlin Township; another begins just north of West Saginaw and extends in a generally northwesterly direction, passing out of the area in the northeastern corner of Beaver Township; still another beach ridge lies west of the Tittabawassee River. The eastern and southern edge of the latter area is very abrupt, rising to a height of about 30 feet above the level lands at the base, but on the west side it gradually slopes away and spreads out almost imperceptibly into the Clyde loam. The area in Juniata Township is uniformly a fine sand; the other areas are mixtures of the two grades characteristic of the type.

All areas of the Miami fine sand, except some of the more recent beach lines, were originally heavily timbered with pine, as was the case with the Miami sand. Since the pine has been removed poplar, willow, cottonwood, and birch constitute the principal forest growth. Some of the better-drained ridges support a growth of oak.

Some corn, oats, rye, timothy, clover, buckwheat, and in a more limited way, Hungarian millet, potatoes, cucumbers, beans, and sugar beets are grown on the Miami fine sand. Cucumbers, potatoes, and rye do well with proper cultivation, but the other crops mentioned give light and uncertain yields. Apples and berries also do fairly well. Much of the type ought to be reforested to pine rather than cultivated to farm crops. At present large areas are valuable only for what pasturage they afford.

The results of mechanical analyses of this soil are given in the following table:

Mechanical analyses of Miami fine sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11785	SE. cor. sec. 28, T. 12 N., R. 3 E.	Fine sand, 0 to 36 inches..	0.1	0.2	0.2	72.1	21.9	2.0	2.7
11783	SE. cor. sec. 8, T. 14 N, R. 5 E.	Medium to fine sand, 0 to 6 inches.	.1	2.8	31.0	58.6	2.5	1.7	3.0
11178	Sec. 14, Frankenlust Tp.	Medium to fine sand, 0 to 8 inches.	.4	8.8	27.8	53.5	4.1	1.9	3.4
11784	Subsoil of 11783	Medium to fine sand, 6 to 36 inches.	.0	2.0	32.1	63.1	.8	.2	1.5
11179	Subsoil of 11178	Medium sand, 8 to 36 inches.	.5	11.7	29.0	46.4	8.0	2.1	2.3

CLYDE GRAVELLY SAND.

The soil of the Clyde gravelly sand, to a depth of from 9 to 12 inches, is a medium-textured, dark-brown loamy sand, or light sandy loam, carrying from 5 to 20 per cent of gravel from one-half to 1 inch in diameter. The subsoil is a rather coarse, incoherent gravelly sand, grading into a mixture of coarse sand and fine gravel at a depth of from 24 to 30 inches. Clay is found at from 4 to 8 feet below the surface. The soil contains a normal amount of organic matter and does not bake or clod under cultivation. The type as a whole is naturally well drained.

The topography varies from gentle slopes along the glacial foothills to low, broad, gently rolling ridges, representing old beach lines, farther out in the lowlands. The type occurs only as the result of beach or shallow-water deposition, although in places it has been influenced to some extent by local wash from the higher lands. The Miami gravelly sand and this type are of the same origin, and are often found associated, but they differ in that the Clyde gravelly sand is more level, more loamy, and a better soil for agricultural purposes.

This soil is found in strips from one-eighth to 1 mile wide on each side of the glacial uplands west of the Cass River, and also as far west as Fairgrove, Akron, and Unionville. Very little specialized farming is practiced on this soil, although all the crops of the area are grown to some extent. Fairly good yields of corn, oats, wheat, rye, timothy, clover, and buckwheat are obtained. Sugar beets, beans, potatoes, and other special crops are grown on a more limited acreage. Sugar beets do fairly well, and the main difficulty is that of getting a good stand. This soil is well adapted to fruit and truck crops and should be devoted more largely to their production.

The following table gives the mechanical analyses of fine earth of typical samples of this soil:

Mechanical analyses of Clyde gravelly sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11773	Cen. sec. 34, T. 14 N., R. 8 E.	Sandy, 0 to 9 inches	4.2	16.1	21.4	36.6	4.6	8.5	8.2
11771	E. cen. sec. 36, T. 13 N. R. 8 E.	Gravelly sand, 0 to 9 inches.	2.3	13.3	19.3	35.8	8.0	12.3	8.4
11774	Subsoil of 11773	Coarse gravelly sand, 9 to 36 inches.	3.5	16.8	27.5	38.5	4.0	3.6	5.8
11772	Subsoil of 11771	Medium to coarse sand, 9 to 36 inches.	2.2	15.8	23.2	36.0	7.6	7.5	7.0

CLYDE SANDY LOAM.

The Clyde sandy loam, in typically developed areas, is a dark-gray or brown medium-textured sandy loam from 8 to 12 inches deep, resting on material of similar texture but lighter color, underlain at 18 inches by a drab or brownish mottled light sandy clay, sometimes tending more toward a sticky sandy loam. Scattered through both soil and subsoil is a small quantity of rounded and subangular crystalline gravel from one-half to 1 inch in diameter, and occasionally some coarser gravel is strewn over the surface. Nowhere, however, is the amount of gravel sufficient to change the structural characteristics of the soil.. The soil carries a fair percentage of organic matter, is easily brought into a good tilth, and does not bake or clod to any extent.

A shallower and heavier phase of the type is a sticky, gray medium to fine sandy loam 8 to 12 inches deep, underlain by a sandy clay. Areas of this character are usually not very large and are a gradation between the typical sandy loam and the Clyde loam. Here the soil crusts and clods rather badly, and generally gives unsatisfactory results when used for crops requiring clean culture. However, for grasses and the small grains the difference is less marked and often inappreciable.

The Clyde sandy loam occurs mostly west of the Saginaw River, and to a less extent in all the townships of the area west of the glacial uplands passing just to the north and west of Caro. An extensive area extends from Saginaw to the northwestern corner of the survey. Around Bay City to the east and northwest are many smaller areas.

The larger areas have a level to gently rolling topography, and are slightly higher than the adjoining areas of the Clyde loam. Occasionally there is a broad, shallow depression, or perhaps a low, broad swell or ridge. The natural drainage of the type is fairly good, but artificial drainage is necessary in places.

The origin of this soil is somewhat varied. The large area paralleling the Tittabawassee River is a water-laid moraine. It seems that this broad elevation was above water before the lower lands on each side and received considerable sandy beach deposits, portions of which have been mapped as a sand. Some of the areas in the vicinity of Bay City also occupy the remnants of an old water-laid moraine, while the remaining areas throughout the survey are derived from beach or shallow-water deposits laid down in somewhat the same way as the Saginaw sandy loam, but now at a higher level and better drained. The large morainic area is formed of the typical Clyde sandy loam as far north as the middle of Williams Township, from which point to the northern corner of Beaver Township it assumes a more variable character, though conforming generally to the shallow-phase description. Nearly all the small areas around Bay City should also be grouped with the shallower phase.

Nearly all of the Clyde sandy loam is devoted to general farming and dairying, the production of sugar beets, beans, potatoes, apples, pears, grapes, etc., being followed also, though less extensively. The crop yields are good, and for general farming this soil ranks next to the Clyde loam—the best general-purpose soil of the area. The smaller areas are undesirable for the production of sugar beets because of the undulating topography and variableness in soil texture. These variations often occur within the limits of a small field, making it impossible to give each a separate treatment, and as a result the beets will be quite irregular in size and quality. Uniform areas, however, give a good growth of beets of excellent quality, and about 10 tons is considered a fair average yield. For beets, especially, the organic content of the soil should be kept as high as possible, and this is best done by following a good system of rotation and giving the fields liberal applications of stable manure.

The results of mechanical analyses of the fine earth of this soil are given in the following table:

Mechanical analyses of Clyde sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11788	SW. cor. of SE. ¼ sec. 12, T. 14 N., R. 8 E.	Medium sandy loam, 0 to 12 inches.	2.4	11.6	11.4	29.1	10.3	21.3	13.2
11786	NW. cor. sec. 13, T. 13 N., R. 8 E.	Medium sandy loam, 0 to 14 inches.	.9	12.6	18.3	28.3	8.5	16.1	14.7
11174	¼ mile NW. of Kawkawlin.	Medium sandy loam, 0 to 10 inches.	1.0	5.8	14.9	29.2	13.0	17.8	18.1
11787	Subsoil of 11786	Coarse sandy loam, 14 to 36 inches.	.9	10.3	16.8	26.3	7.3	16.4	21.7
11175	Subsoil of 11174	Sticky sandy loam, 10 to 36 inches.	1.8	7.2	13.6	24.3	11.1	18.2	23.6
11789	Subsoil of 11788	Light loam, 12 to 36 inches.	2.7	10.1	11.2	20.7	10.1	21.4	23.7

SAGINAW SANDY LOAM.

The Saginaw sandy loam is a more loamy phase of the materials which give rise to the Clyde sand, and its origin, mode of occurrence, and drainage features are essentially the same as those of that type, namely; lacustrine deposition, level topography, and naturally deficient drainage. The soil to a depth of from 12 to 15 inches is a dark-gray to black medium-textured sandy loam carrying a high percentage of organic matter, which has accumulated as a result of poor drainage conditions. The soil is loose, mellow, and easily kept in good tilth. The subsoil is a dark-gray sandy loam of about the same texture as the soil to a depth of from 2 to 2½ feet, where it is underlain by a heavy blue silty clay.

Occupying, as it generally does, an intermediate position between the Clyde sand and Clyde loam, the type varies from a sandy loam, as above described, to a heavier gray or black sandy loam underlain by clay at less than 2 feet. The heavier areas have a tendency to clod and bake, partly on account of the heavy character of the soil and partly because these areas are either now or else recently have been in a poorly drained condition.

The principal areas of the Saginaw sandy loam are found in Bangor, Hampton, Merritt, Frankenlust, Saginaw, Buena Vista, Akron, Wisner, and Sebewaing townships. Smaller areas are found in other parts of the survey. Areas extending along the Saginaw River are rather more sandy than the remainder of the type.

When properly drained, this is a very desirable soil for a great variety of crops. The soil contains considerable organic matter, retains moisture well, is sandy enough to be easily handled, and at the same time is susceptible of lasting improvement, as clay is rarely over 2½ feet below the surface. In places trucking is the principal industry, and such crops as cabbage, cauliflower, tomatoes, potatoes, cucumbers, cantaloupes, and beans are grown with very satisfactory results. Sugar beets and chicory do well, this being one of the principal chicory soils of the area. In respect to general crops, some corn, wheat, oats, timothy, clover, buckwheat, etc., are grown. Beets will yield from 10 to 20 tons per acre, chicory about 10 tons, corn from 35 to 50 bushels, and wheat from 15 to 30 bushels. In connection with general farming some cattle are generally kept for dairy purposes.

Parts of the type are still undrained and used only for summer pasturage. Some of the lands mapped as Meadow between Bay City and Saginaw would be classed as the Saginaw sandy loam if reclaimed.

The following table gives the results of mechanical analyses of representative samples of this soil type:

Mechanical analyses of Saginaw sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11792	NW. cor. sec. 2, Merritt Tp.	Medium sandy loam, 0 to 14 inches.	1.0	8.5	21.3	43.9	7.9	10.6	6.6
11790	E. cen. sec. 21, T. 14 N., R. 6 E.	Medium sandy loam, 0 to 12 inches.	.7	6.9	22.0	33.5	8.7	19.5	8.7
11793	Subsoil of 11792......	Medium sand, 14 to 30 inches.	1.1	8.5	19.5	48.8	8.8	8.2	4.7
11791	Subsoil of 11790......	Medium sandy loam, 12 to 24 inches.	1.9	9.0	20.1	34.0	8.5	16.5	9.2

CLYDE STONY SANDY LOAM.

The Clyde stony sandy loam is a medium-textured, gravelly sandy loam, 18 to 24 inches deep, underlain by a sandy loam or mottled brown clay loam containing a small amount of gravel. The color of the soil varies from a dark brown near the surface to a lighter brown in the lower depths. The soil proper is from 10 to 12 inches deep, and generally contains from 5 to 10 per cent of gravel from one-half inch to 2 inches in diameter.

A more noticeable characteristic of the type is the large number of bowlders strewn over the surface and occurring to a less extent below the surface. These bowlders are mainly of granite and range from large rounded gravel to angular fragments 2 or 3 feet in diameter. In bringing the soil under cultivation the larger gravel and bowlders are removed and piled in large heaps or else hauled away and used for building purposes or for the construction of fences around the fields. With the stones removed from the surface, the soil is a good friable sandy loam, slightly more porous than is usual with soils of this class on account of the small gravel present. A few local areas are entirely free from gravel.

Excepting a few small areas in Columbia Township, this type is found only east of the Cass River, where it is associated with the Miami sand. It is of glacial or lake origin, has level to generally rolling topography, and is naturally fairly well drained in the larger areas. Some of the smaller areas receive seepage from the higher lands, while others are hemmed in on all sides by more elevated areas of sand and have only a sluggish drainage outlet, if any at all.

The greater part of this soil type is in an improved state and used mainly for general farming. Sugar beets, beans, cucumbers, and potatoes are grown on a small scale. Corn will yield from 25 to 40 bushels, oats from 20 to 50 bushels, wheat from 15 to 20 bushels, beans from 10 to 20 bushels, hay from 1 to 1½ tons, and sugar beets anywhere from 7 to 15 tons, per acre.

The results of mechanical analyses of the fine earth of this soil are given in the following table:

Mechanical analyses of Clyde stony sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11769	S. cen. of SW. ¼ sec. 8, T. 12 N., R. 10 E.	Medium sandy loam, 0 to 12 inches.	1.0	6.2	13.1	40.8	11.5	18.5	8.7
11767	NW. cor. sec. 15, T. 12 N., R. 10 E.	Medium sandy loam, 0 to 10 inches.	1.5	6.2	10.6	44.3	13.2	14.0	9.7
11770	Subsoil of 11769	Sandy loam, 12 to 36 inches.	1.1	6.2	12.9	40.3	10.5	18.0	10.5
11768	Subsoil of 11767	Sandy loam, 10 to 36 inches.	1.0	4.9	10.7	41.1	14.8	15.0	11.8

CLYDE FINE SANDY LOAM.

The soil of the Clyde fine sandy loam, to a depth of from 9 to 12 inches, is a very fine sand to fine sandy loam of a brownish-gray or brown color, very homogeneous in texture, friable, and easily kept in good tilth. The subsoil is a brown or yellow fine sand or fine sandy loam to a depth of 2 feet or more below the surface, overlying a clay similar to the subsoil of the Clyde loam. Both soil and subsoil are entirely devoid of gravel.

This soil is found principally west of the Saginaw River. Two large areas parallel the Tittabawassee River, one on each side. Other large areas are found in Williams, Beaver, Kawkawlin, and Monitor townships. Several smaller areas were mapped in other parts of the survey, the most important being in Brookfield Township.

The type is slightly undulating to rolling in topography, and a field under cultivation will often present a billowy appearance from the numerous small hillocks and narrow depressions running in all directions. Again, whole farms will be nearly level. Some of the smaller areas are wind-blown beach deposits, occurring in the form of low ridges, while the larger areas seem to be the result of deltas formed in the old lakes that once covered the area. These areas have subsequently been modified by wind and wave action on the subsidence of the lake. The broad strips along the Tittabawassee River no doubt represent ancient deltas, as do the large areas in Beaver, Kawkawlin, and Monitor townships. The areas in Williams Township seem to be mostly wind-blown beach deposits.

The drainage of the type varies largely with the state of development and local physiography. In an undeveloped state the ridges are generally high enough to be naturally well drained, while the intervening depressions are often in a swampy condition. A growth of tamarack is commonly found in the narrow, mucky strips, which support also a jungle of water-loving plants. Where farmed the drainage of the type has, of course, been improved by artificial means.

Besides the products of general farming and dairying, sugar beets, beans, and potatoes are important crops, and, to a less extent, chicory, apples, pears, grapes, and vegetables. Corn will yield from 20 to 40 bushels per acre, oats from 30 to 60 bushels, beans from 10 to 25 bushels, hay from 1 to 1½ tons, beets from 10 to 15 tons, and chicory from 7 to 12 tons.

The more level areas are well adapted to sugar beets, but, as with the Clyde sandy loam, in order to get uniformly good results it will be necessary to keep the soil liberally supplied with organic matter, which can be accomplished by applying manure and practicing a well-planned system of rotation. Though this is a porous soil tile drainage will prove very beneficial, especially where beets are to be grown. The comparatively shallow depth to clay subjects some of the lower lying areas to sidehill seepage, a condition that can best be provided against by tile drains.

The results of mechanical analyses of this soil are given in the following table:

Mechanical analyses of Clyde fine sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11794	W. cen. sec. 23, T. 12 N., R. 3 E.	Very fine sand, 0 to 12 inches.	0.1	0.2	0.3	18.7	64.5	8.9	6.8
11796	NW. cor. sec. 28, T. 14 N., R. 3 E.	Very fine sandy loam, 0 to 9 inches.	.1	.7	.9	12.7	35.0	41.4	8.7
11795	Subsoil of 11794	Fine sand, 12 to 36 inches.	.0	.3	.2	34.8	49.7	12.2	2.6
11797	Subsoil of 11796	Fine sandy loam, 9 to 30 inches.	.0	.4	.6	18.9	41.5	30.1	8.3

MIAMI FINE SANDY LOAM.

The Miami fine sandy loam is a medium to fine sandy loam, 18 to 24 inches deep, underlain by a brown mottled clay loam. The color of the soil is a brownish gray to a depth of about 12 inches, below which it is a light brown to the clay line. The soil contains a rather small percentage of organic matter, and on drying after a rain the surface often has a light ashy appearance. It also has a tendency to bake and crust to a limited extent when used for crops requiring clean cultivation. A small amount of gravel is common to the type, being more abundant in the soil than in the subsoil.

A lighter phase of the Miami fine sandy loam, which occurs so intermixed with typical areas that the two can not well be separated, is a slightly gravelly fine sand, 18 to 24 inches deep, overlying the clay, with surface features and colorations about the same as in typical areas. This phase is used for the same crops, and the yields are essentially the same as with the typical soil.

The Miami fine sandy loam is found only in the eastern part of the area. The larger areas are in the southeastern corner of the survey, between Gagetown and Cass River, along the eastern border. Smaller areas are scattered through the morainic uplands extending in a southwesterly direction from Gagetown.

The topography is that of typical morainic uplands, very hilly and undulating, with local variations in elevation from 10 to 50 or more feet. The general elevation is about 100 feet above the leveler lowlands. The drainage, as a rule, is very good, and in some places on the ridges and hillsides excessive. Some of the depressions are springy and often contain small areas of Muck.

Nearly all of this type of soil is cultivated to general farm crops, and in a limited way to sugar beets, beans, and potatoes. Some attention is also given to dairying and to apples, pears, and grapes, to which fruits it is specially adapted. The crop yields range from light to medium, being somewhat variable on account of the broken topography occupied by the type.

The following table gives the results of mechanical analyses of the fine earth of samples of the soil and subsoil of this type:

Mechanical analyses of Miami fine sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11761	N. cen. sec. 4, T. 11 N., R. 10 E.	Fine sandy loam, 0 to 18 inches.	1.3	8.0	11.4	27.3	11.5	26.7	13.6
11759	E. cen. NE. ¼ sec. 18, T. 12 N., R. 8 E.	Fine sandy loam, 0 to 18 inches.	3.5	10.5	14.7	22.8	8.2	22.3	17.9
11762	Subsoil of 11761	Clay loam, 18 to 36 inches.	.5	4.9	8.9	22.1	11.2	25.8	26.6
11760	Subsoil of 11759	Clay loam, 18 to 36 inches.	1.9	8.5	8.9	17.5	8.8	26.4	27.9

CLYDE SILT LOAM.

The Clyde silt loam is a light to chocolate-brown silt loam 10 inches deep, resting upon a similar silt loam of a lemon-yellow color and containing little or no organic matter. The texture is very homogeneous to a depth of 3 feet, and gravel is entirely absent, except for a number of bowlders strewn over the surface, which are removed when the land is being brought under cultivation. The soil is very friable and easily kept in good tilth.

The type is of very limited extent, and occurs in a single area lying north of Gagetown, in Brookfield Township. Its origin is somewhat uncertain, but it seems to be derived, as is the greater part of the Clyde fine sandy loam, from material carried by streams into the glacial lake and there deposited. The topography of the type is somewhat rolling and its drainage fairly good.

The soil is devoted to general farm crops, and in a limited way to the production of chicory. It is well adapted to grain and hay, and the yields are good.

The results of a mechanical analysis of this soil are given in the following table:

Mechanical analysis of Clyde silt loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11806	SW. cor. of NE. ¼ sec. 26, T. 15 N., R. 10 E.	Friable silty loam, 0 to 36 inches.	0.2	0.9	1.0	2.9	11.5	64.9	18.2

MIAMI CLAY LOAM.

The Miami clay loam occurs in two phases, which are very intimately associated and seem to be of the same agricultural value. The more extensive phase, and therefore what may be considered the typical soil, is a friable brown loam of a silty nature, 8 to 12 inches deep, underlain by a mottled brown clay loam to undetermined depths. The other phase is a light-brown fine sandy loam, 8 to 12 inches deep, underlain by the same kind of clay loam as above described. A very small amount of gravel is common in soil and subsoil of both developments of the type.

There are other minor variations in the type, as a result of different conditions of drainage and a consequent difference in the organic matter content of the soil. The areas occupying knolls and ridges generally carry a low percentage of organic matter and the soil is of a light-brown color, often appearing very light at the surface, and this is true whether the areas are typical or of the lighter phase of the soil. In the draws the soil takes on a blacker color, and except where there has been considerable coarse wash from the hillsides it resembles the Clyde loam of the lowlands. All of these variations may occur in a field of 10 acres or less, and except in a general way the topography offers no index as to what kind of soil is to be expected in certain places.

The Miami clay loam is a typical morainic upland soil, with local elevations varying from 10 to 40 feet and reaching a general elevation of 100 feet above the adjoining lowlands. The natural drainage is very good, except in small depressions with impeded or obstructed outlets.

The type occurs as a prominent ridge running through Juniata, Indian Fields, Almer, Ellington, and Elmwood townships in a northeasterly direction, paralleling the Cass River. A few small areas are found in the southeastern corner of the survey, associated with the Miami fine sandy loam.

Besides the general farm crops, sugar beets and beans are grown to a considerable extent. On most of the farms at least a few dairy cattle are kept. The crop yields are not so good as those on the Clyde loam of the lowlands. The yield per acre of corn ranges from 20 to 40 bushels; of oats, from 40 to 60 bushels; of wheat, from 15 to 20 bushels; of beans, from 10 to 25 bushels; of hay, from 1 to 2 tons, and of beets, from 7 to 15 tons.

The main difficulty in beet culture is getting a good stand. The trouble is due largely to the fact that the soil does not contain a sufficient quantity of organic matter to keep it from baking and crusting, and many of the young plants fail to break through the hardened surface. There are two remedies for this condition—either to look after these soil crusts when the young plants are coming up or else—

and this gives more lasting results—to incorporate larger amounts of organic matter with the soil by proper crop rotation and the application of stable manure.

The results of mechanical analyses of fine earth of this soil are given in the following table:

Mechanical analyses of Miami clay loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11763	E. cen. of NE. ¼ sec. 12, T. 12 N., R. 8 E.	Light friable loam, 0 to 9 inches.	0.5	6.8	9.4	24.2	9.9	28.3	21.2
11765	N. cen. sec. 27, T. 13 N., R. 9 E.	Medium loam, 0 to 9 inches.	.7	5.2	7.5	19.8	10.1	32.6	24.1
11764	Subsoil of 11763	Friable clay loam, 9 to 36 inches.	.4	5.4	6.8	24.7	10.8	28.1	23.8
11766	Subsoil of 11765	Clay loam, 9 to 36 inches.	1.6	3.9	5.5	13.8	9.2	33.4	31.9

CLYDE LOAM.

The soil of the Clyde loam ranges from a moderately friable loam to a rather heavy compact loam of a dark-gray, brown, or black color and from 8 to 12 inches deep. This rests upon a sandy or silty drab-colored clay, somewhat streaked and mottled with iron stains. On account of former inadequate drainage the soil is still largely in a puddled, compact state, sticky and impervious when wet and very hard when dry. The effect of poor drainage is emphasized where the type is found in low-lying areas that have been under cultivation only a short time. Here the soil proper is usually shallow and sticky, and clods badly when plowed. If these clods are allowed to dry before the field has been rolled or harrowed they are very hard to crush, and it is almost impossible to reduce the soil to good tilth.

In the native state the soil possesses marked clayey properties to within a few inches of the surface, where there is an accumulation of organic matter, but the more mucky areas are naturally loamy and mellow. The type is best developed in the older settled and better drained areas. The soil here is mellow and does not bake or clod to a great extent. The subsoil, too, is more friable and pervious to water.

This soil occurs in every township west of Cass River and is by far the most extensive type of the area. In places it is developed almost to the exclusion of all other types. Only four small areas, aggregating less than one-fourth of a square mile, were mapped east of Cass River. The type is being extended from year to year by burning off large areas of peat.

The Clyde loam has an almost level surface. A slight unevenness sometimes occurs in the form of low knolls and shallow depressions, and occasionally as low, broad swells with intervening broad, shallow depressions, through some of which the small streams of the area flow.

The drainage of the type is naturally very poor on account of the level character of the country. The small streams were inadequate for thorough drainage, but they have been straightened and enlarged and supplemented by an extensive system of open drains, and altogether fair surface drainage now exists. The open drains are being supplemented by tile drains, and this phase of the drainage question is receiving more attention every year. The type is derived from glacial-lake deposits that have not been modified to any extent by subsequent stream action.

A very large part of this soil type is in an improved state, and the remainder is susceptible of improvement. The usual crops of the area are successfully grown. Dairying is an important industry, receiving some attention by nearly all farmers. Corn will yield from 40 to 60 bushels per acre, oats from 40 to 60 bushels, wheat from 15 to 30 bushels, and the other grains, including rye, barley, and buckwheat, proportionately well. Timothy and clover yield from 1 to 2 tons, and sugar beets from 10 to 20 tons, per acre. All the fruit and truck crops of the section are grown on a small scale.

The Clyde loam is the principal sugar-beet soil of the area, and offers advantages for a further extension of this important industry.

The results of mechanical analyses of samples of this soil are given in the following table:

Mechanical analyses of Clyde loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11176	2 miles W. of Kawkawlin.	Loam, 0 to 12 inches	0.5	4.2	8.5	17.1	21.0	26.1	22.6
11798	N. cen. sec. 22, T. 13 N., R. 8 E.	Medium loam, 0 to 9 inches.	1.1	4.1	7.4	18.8	9.7	33.4	25.5
11800	SE. cor. sec. 17, Buena Vista Tp.	Mellow loam, 0 to 12 inches.	.9	5.1	7.8	15.7	8.1	27.7	34.8
11177	Subsoil of 11176	Clay loam, 12 to 36 inches.	.8	4.9	8.6	16.9	19.3	24.7	24.6
11799	Subsoil of 11798	Clay loam, 9 to 36 inches	1.1	4.6	7.3	18.4	8.3	31.2	28.6
11801	Subsoil of 11800	Clay, 12 to 36 inches	.7	3.6	6.8	13.0	6.9	27.1	41.7

The following samples contain more than one-half per cent of calcium carbonate ($CaCO_3$): No. 11799, 3.1 per cent; No. 11801, 5.3 per cent.

CLYDE CLAY.

The soil of the Clyde clay to a depth of from 6 to 9 inches is a silty clay loam of a somewhat marly nature. The color and structural characteristics vary directly with the amount of organic matter present. Where the percentage of organic matter is low the soil is of a rather light gray color, is compact, and bakes and clods badly under the plow, while where the proportion of organic matter is higher the soil is of a darker, blackish color and a more loamy, friable nature. The subsoil is a bluish or drab-colored clay, very tenacious, and practically impervious to water.

The marked clayey properties of this soil are not due altogether to the actual heaviness of the soil material, but partly to a puddled condition of the soil particles as a result of a long-continued waterlogged condition, giving it a compact, clammy consistency. Some of the larger areas mapped as this type were originally covered with accumulations of peat, under which were marly accumulations often an inch or so in thickness. When the superficial organic matter was burned off the marl was left, which accounts for the marly properties of the soil already mentioned.

The Clyde clay is the heaviest phase of the old lake bottom deposits and occupies low, wet level areas where sufficient drainage has been provided to make farming practicable. Its origin is about the same as that of the Clyde loam, except in the case of the large areas skirting the meadow lands between Bay City and Saginaw. Here both the Meadow and the Clyde clay areas occupy a small lake bottom that existed after the surrounding lands had appeared permanently above water level, and it is possible that a considerable amount of the fine material brought down by Saginaw River was deposited in this lake for quite a long time. That portion of the lake bed mapped as Meadow if reclaimed would be mainly classed as the Clyde clay.

The next largest area occupies a part of an old swamp bed in Brookfield Township, in the northeastern corner of the survey. The greater part of this area was originally covered with peat, which has recently been burned off, leaving the underlying clay with just enough organic matter and ashy material to render it fairly loamy. Other areas are found associated with areas mapped as Muck in Buena Vista, Merritt, and Gilford townships. Two small areas were also found in the southern part of Thomastown Township.

The greater part of the type is in an improved state and is used for general farming and for sugar beets and truck crops. With good drainage the yields would be about the same as those on the Clyde loam. However, the type as a whole is not under the best conditions of drainage, and the crops are somewhat uncertain.

Until better drainage is provided the possibilities of this soil will never be realized. Better drainage and deeper and more thorough plowing will go a long way toward making it one of the most desirable soils of the area for general farming and for beet production. Some of the lighter textured soils are better suited for truck crops.

The results of mechanical analyses of samples of this soil are given in the following table:

Mechanical analyses of Clyde clay.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11804	S. cen. sec. 8, Buena Vista Tp.	Silty clay loam, 0 to 7 inches.	0.7	6.8	6.3	15.7	4.1	30.3	35.7
11802	E. cen. of NE. ¼ sec. 8, T. 12 N., R. 6 E.	Heavy clay loam, 0 to 9 inches.	.6	8.1	7.1	12.8	5.1	28.2	38.0
11805	Subsoil of 11804	Clay, 7 to 36 inches	.7	4.5	6.6	12.8	4.9	20.9	49.5
11806	Subsoil of 11802	Clay, 9 to 36 inches	.9	3.2	2.4	7.0	4.2	30.1	51.8

The following samples contain more than one-half per cent of calcium carbonate ($CaCO_3$): No. 11802, 1.3 per cent; No. 11806, 24 per cent; No. 11804, 8.4 per cent; No. 11805, 18.7 per cent.

MUCK.

True Muck consists of an accumulation of vegetable remains in an advanced stage of decomposition, usually black in color, very finely divided, and very mellow. In the present areas there are large bodies answering this description, but the material varies and ranges from almost pure organic matter to a mixture of organic matter with varying though small proportions of earthy material. The depth ranges from 1 to 3 or more feet, at which depths clay, or more rarely sand, is found. Where the material is almost wholly organic matter in the earlier stages of decay the areas would be classed as Peat, but no attempt was made to separate such areas in this survey. In the deeper Muck areas at the line of contact between the soil and clay subsoil there is usually found a stratum of marly material from 1 to 6 inches in thickness.

The largest areas of Muck extend in an almost continuous strip from east of Saginaw to within 2 miles of Akron on the west. This strip once continued over large areas in Merritt, Gilford, and Wisner townships, but as a result of fires at least half of the original area has been burned over, which has so changed its character that it can now be mapped as the Clyde loam or Clyde clay. Other areas are found along the bay front and in the southeastern and other parts of the survey.

Muck originates in low, wet areas where swampy conditions have continued over very long periods. Such areas support a luxuriant growth of water-loving grasses, rushes, and sometimes thick forests of tamarack or elm, and the organic remains of these plants, accumulating faster than they decay, give rise to the material constituting the type as mapped in the Saginaw area.

Only a very small proportion of the Muck is under cultivation, the chief crops being corn, hay, and sugar beets, with smaller acreages in cabbages and onions. Though Muck is an ideal soil for potatoes, celery, and onions, very little attention is given to such crops. Peppermint growing might prove profitable here, as it has on the Muck soils of other parts of Michigan.

Instead of using Muck for what it is particularly adapted to, the farmers of the Saginaw area seem usually to prefer to burn the more peaty areas off and use the underlying soil for general farming. This is advisable in some instances, but the wholesale destruction of these peaty accumulations is not to be commended. In all cases where the soil is burned care should be taken that enough organic matter is left to be incorporated with the underlying clay or sand, which is often nearly devoid of organic matter.

MEADOW.

The Meadow, as classified in the Saginaw area, includes areas along the bay front and stream courses where the water table is permanently maintained within a few inches of the surface or where the surface is subject to intermittent overflows. Such areas are unfit for any of the cultivated crops, but generally support a rank growth of water-loving grasses and rushes, affording some summer pasturage and, in the better places, a limited quantity of hay. The areas bordering the streams are usually in forest.

The largest area of Meadow extends along the Saginaw River from Saginaw to Bay City. This area is very level and is occasionally overflowed to a depth of several feet. The water table is nowhere more than from 6 to 12 inches below the surface, and some small patches are actually under water the year round. These wetter places are of a real swampy nature, but their mode of occurrence was such that they were not included as Swamp. This whole area is practically treeless, and is covered everywhere with coarse grasses and rushes. Other areas of similar character are found along the bay front.

The greater part of the Meadow strip along the Tittabawassee River is fairly dry during the summer months, and in a few places is being farmed. Corn and hay are the principal crops grown, and they do well in favorable seasons, but the uncertainty of yield, due to wet seasons and overflows, makes farming unsatisfactory. This strip is partly forested and affords good summer pasturage.

The strips of Meadow along the smaller streams are more variable in character and often approach a swampy condition.

The reclamation of the larger areas of Meadow, especially the one between Saginaw and Bay City, would be a profitable investment. The feasibility of such an undertaking is illustrated in the Fifield farm, which covers portions of sections 27, 28, 33, and 34 of Zilwaukee Township. This farm has been reclaimed from the condition of Meadow and could be mapped as Clyde clay, and much of the remainder of this Meadow area could be changed in like manner. If undertaken in a systematic and businesslike manner the whole area along the Saginaw River could be diked and drained at a much less cost than the land would be worth under cultivation, while in its present condition it is practically of no agricultural value.

SWAMP.

Swamp is an earlier stage of the conditions giving rise to Meadow lands and refers to areas partially covered by water and of no agricultural value except for such pasturage as is afforded by rank water grasses and rushes during dry seasons. Only three limited areas of Swamp were mapped, two along the bay front and one occupying a small island in Cass River, 2 miles south of Caro. The area in Wisner Township lies immediately along the water, while the larger area to the northwest of Bay City occupies a low depression, with an inlet from the bay, and is only partially covered by water, except when the higher tides occur.

DRAINAGE.

The Saginaw Valley proper, in which a greater portion of the area surveyed lies, is level to gently rolling, and in places only a foot or so above the level of Saginaw Bay. The general slope of the valley is gentle, and the secondary streams are small and sluggish. The more rolling lands are usually sufficiently high to afford fair natural drainage, but these areas are generally underlain by an impervious clay at a depth of 10 feet or less, thus causing much of the underground water of the higher areas to appear again at the surface on the lower levels. As a result of these conditions of poor natural drainage a large proportion of the area was originally in a semiswampy condition, imparting to some of the heavier types of soil a compact, impervious consistency that has not yet been entirely corrected by better drainage.

A large percentage of the area is now under cultivation, but a great deal of artificial drainage was necessary before any extensive use of the land was possible. Nearly all of the small streams have been straightened and enlarged, or else supplanted by large open ditches or canals, often many miles in length and emptying directly into the larger streams or bay. Except in undeveloped areas, ditches of various sizes are found along nearly every section line and sometimes along half sections. Some of these are only large enough to remove surface water in wet seasons, but others provide both surface and subsurface drainage, the latter in places to a depth of 6 or 8 feet below the surface.

Notwithstanding the extent of these improvements, the most important problem confronting the agricultural interests of the area is still that of drainage. In wet seasons some of the most important crops are little better than failures, while in dry seasons the same soils lose their moisture rapidly by surface evaporation, or else become hard and impervious, making it difficult for the roots to penetrate the soil and reach the moisture present at greater depths. A wet soil is cold, often compact, impervious, and hard to keep in good tilth. If of the heavier types it bakes and clods badly at the surface. The crops will be shallow rooted and irregularly developed over the field. Such soils are poorly aerated, and the biological and chemical changes necessary to a productive soil go on very slowly. On the other hand, thorough drainage not only removes all surplus water to below the root zone, but renders the soil warmer, gives better aeration, improves structure and effectively deepens the soil, besides improving the chemical constitution. The effect of good drainage is pronounced upon any of the ordinary farm crops, but especially so with those crops where quality counts for as much as quantity, as with the sugar beet.

These facts are being realized by the better class of farmers, and they are not only seeking better general drainage outlets, but are also making considerable headway in tile-draining their lands. Their verdict is that the cost of tiling, where properly done, is often paid for in the increased yields of a single crop. Others admit the benefit to be derived from tile drainage, but for one reason or another are slow about making such improvements. Around railroad stations where tile can be had easily the greater amount of tiling is done, and it is safe to say that if there were more tile factories scattered through the area there would be a vast extension of this important branch of drainage.

Considerable areas covered by the survey are still in an undeveloped state because of a lack of drainage. Among these may be mentioned the large Meadow and Muck areas, and parts of the Miami sand areas. These would be very valuable lands if reclaimed, and with few exceptions reclamation is feasible.

In Michigan drainage is made a public work under the direct charge of county drainage commissioners appointed every two years by the county supervisors. The law is such that much more extensive systems are made possible than if left to individual effort, and the cost to the farmer is generally less than it would otherwise be. Where the county constructs a drain the farmers to be benefited are assessed an amount proportional to the benefits received.

AGRICULTURAL METHODS.

Though quite a variety of crops is grown in the area, not a great deal has been done in the line of specialization. On the other hand, it is quite common for a single farmer to grow nearly all of these crops regardless of the soil type or types he has to cultivate. The tendency to-day, however, is more toward specialization, and the necessity for more intensive methods is being more keenly felt as new crops are introduced and as the agricultural industries grow older.

The farmers may be divided into two general classes—those devoting all of their time to a system of general farming, in connection with which are kept at least a few dairy cattle and more rarely beef cattle and sheep, and those dividing their attention between the foregoing system and the production of special crops, as sugar beets, beans, potatoes, chicory, cucumbers, and many others of less importance. A few farmers devote all their time to trucking, while a few others have gone into dairying on an extensive scale. In either of the two principal systems of farming the scheme is generally such that much of the crude products of the farm, usually commanding low prices in the market, is consumed at home by dairy and beef cattle, and thus converted into products commanding much higher prices. Besides this, the systems have the advantage of returning to the soil from year to year great quantities of fertilizing materials that under another system would be lost.

The methods of tilling, cultivation, and harvesting are not essentially different from those of other sections of the North Central States. All of the latest improved machinery is being used. Some of the farmers prepare their soils and cultivate their crops in a very thorough manner, but with others there is a decided lack of thoroughness. In preparing the seed bed the plowing is often shallow, and as a result much of the rainfall runs off instead of soaking into the soil, and the crops suffer unnecessarily from short droughts. This condition is aggravated by a failure to keep the fields properly mulched by frequent cultivations during the dry weather. The difference in the crop yields is as great as the difference in the agricultural methods employed, and careful preparation and cultivation are well paid for in the increased yields.

Sod and stubble lands intended for corn are usually given one plowing in the fall and allowed to stand until the following spring, when they are again broken and harrowed to reduce the clods. The plowing ranges from 4 to 8 inches in depth, and is done with a two or four horse turning or rotary disk plow. Many of the farmers wait until spring to do their plowing, especially if the soils to be used for corn were clean cultivated the preceding year. As soon as the danger of frost has passed the corn is planted in rows usually about 3½ feet apart. The distance in the rows varies from 18 inches to 3 feet. The corn is planted with listers or some other form of planter. From two to four grains are put in a hill, and all are allowed to mature. Some farmers plant their corn in check rows, so that it can be cultivated in both directions. The after cultivation is done with harrows and cultivators made for the purpose.

When the corn is ripe it is cut with harvesters or by hand and shocked to cure. Later in the fall the corn is husked and the fodder is housed for roughage.

Some spring wheat is planted, but the greater proportion of this crop is planted in the late summer or early fall, in August and September, so that the young plants will have time to make a fair growth and become well established in the soil before the winter sets in. For this crop the soil is broken once or twice with a two or four horse turning plow and then harrowed and rolled to reduce the clods. In case manure is applied it is distributed broadcast over the fields before they are plowed. When the soil is in shape the wheat is drilled in. The other small grains are planted in the same way, except that the time of planting varies somewhat. Oats, being easily winterkilled, are planted in early spring, as soon as the soil can be handled without injury.

The small grain crops are ripe in July and August. Nearly all of the harvesting is done with self-binders. When cut the grain is shocked in the field to dry and then hauled to the barn and stored or stacked on the outside to stand until the thrashing machines make their rounds later in the season. The straw is stacked and used for roughage and stable litter.

Grass lands are prepared as for corn or wheat. If grown separately, the clover may be sown along with the wheat or oats, which acts as a nurse crop the first year. Much of the timothy is planted separately, but some plant timothy and clover together. The mixed hay is supposed to represent more nearly a balanced ration for stock than either separately. The main difficulty with this system is that the clover blackens with the least exposure to rain during the process of curing, and thus reduces the market value of the hay. The second crop of clover is generally cut for the seed.

The most urgent needs of the sugar-beet crop are more attention to soil adaptations, better seed, better drainage, more thorough preparation and cultivation of the soil, and the elimination of as much hand labor as possible by machinery. The growing of sugar beets being decidedly a matter of intensive farming, it is difficult for the ordinary farmer to realize the real needs of this crop. The drainage situation of the area most seriously concerns the sugar-beet industry, as this crop will not develop properly in a soil kept too wet, and, moreover, the sugar content in crops grown on such soils is proportionately low.

The testimony obtained shows that there are a few soils which under no circumstances can be recommended for the crop; that there are several upon which, by careful treatment and in favorable seasons, excellent results may be obtained; and that there are a few, but these among the most widely distributed, which give the best results from year to year and are the ones upon which the industry should be chiefly developed. Those which should be avoided are the light sandy types, including the Miami sand and the Miami fine sand. Under this heading would come such gravelly soils as are composed chiefly of sand or gravel. Among those which may, under favorable circumstances, produce good results, but which can not be unqualifiedly recommended, are the upland soils, the Muck soils, the Clyde fine sandy loam, the Clyde clay, and the Clyde sand. Those which are considered excellent soils for beets, and upon which it is recommended that the industry be mainly developed, are the Clyde loam, the Clyde sandy loam, and the Saginaw sandy loam. Of these three the latter is relatively so limited in extent that it can hardly be considered an important beet type. The Clyde loam is the best, producing the most uniform and satisfactory results. It is the most widely distributed of all the lowland types, covering, in all probability, considerably more than half the area of the old lake bed formation and 38 per cent of the area of the Saginaw survey.

The Clyde sandy loam is also of wide distribution and should be ranked second to the Clyde loam as a sugar-beet type. The character of this soil is a little more variable, and results are not quite so uniform, but on the whole it is to be highly recommended as a beet soil.

The facts obtained point also to the conclusion that even among the types best suited to beet growing different methods are required to meet the needs of each soil, and the grower must study these characteristics to the end that he may adapt his methods to the particular requirements of each.

Apparently little difference was found in the sugar-producing power of the various kinds of soil, those which average lower being the ones which tend to produce a large beet, such as the Muck soils. But the difference, though comparatively small, is of considerable importance in view of the necessity for maintaining a high standard of quality.

Chicory soils are prepared and handled about the same as for sugar beets, and the growth of the two crops requires about the same amount of labor. The methods of handling the truck soils are quite varied, and can not be separately treated here. In general, however, soils intended for trucking are prepared much more thoroughly than for any of the general farm crops, and in places fertilizers and stable manures are liberally used.

The stock, including dairy and beef cattle, sheep, and horses, grown for market, are pastured during the summer on the unimproved lands and on other areas reserved for the purpose, and sometimes on the grass lands after the hay has been cut. In the winter all of the stock has to be housed and cared for.

Dairying is an important industry. The milk is handled by creameries and cheese factories located at convenient intervals throughout the area. These are generally run on an independent basis and a fixed price is paid for the milk. The creamery prices are for the butter fat, while the skim milk goes back to the farmer for feeding purposes.

A more or less satisfactory rotation is practiced by all the farmers. There are several systems in operation, some of which are followed out without having any special object in view, while others are designed to get the best results from the soil without impairment of its productiveness. The number of crops used in the rotation varies with different farmers. A system followed by a great many of the beet and bean growers includes a six-year rotation, as follows: Two years in timothy or clover, followed by corn, beans, beets, and wheat or oats, succeeding each in the order named.

AGRICULTURAL CONDITIONS.

On many of the better types of soil mapped there is general prosperity among the farmers. A majority of them are out of debt and saving money. The farmhouse is usually a well-built two-story frame or brick building, painted and kept in good order. The outbuildings are as good as those to be found in any agricultural community. The barns are usually large and have a concrete, stone, or brick basement. The cost of building these farmhouses ranges from $1,000 to $2,500 each, and occasionally more, while the range in the cost of the barns is from $800 to $2,500. An outlay of $5,000 in farm buildings is of not uncommon occurrence.

There is a less thrifty class who are making only an indifferent living as a result of a bad start, poor soils, or infrugal methods. At least a few of this class are to be found in all parts of the area, but more generally on some of the less desirable soils.

Taken as a whole, the best improvements in the area are to be found on the Clyde loam, with the Clyde sandy loam second, while the poorest improvements are on the Miami sand and Miami fine sand. Here the farms are very scattering and generally poorly equipped, except where some of the special crops to which these soils are best adapted are being grown.

Nearly all of the farmers have the advantage of rural free delivery, and some of them have telephone connections with Saginaw, Bay City, and other smaller towns.

One of the strongest evidences of the agricultural capabilities of the soils of the area and its general prosperity is that many farmers who started in the area with little, if any, capital, living at first in small, rudely constructed cabins that could hardly be called comfortable, after a period of years are found replacing these by the better class of residences characteristic of the area.

The proportion of mortgaged farms in some parts of the area is higher than in other sections of Michigan. This is not the result of a depressed condition among the farmers, but rather is due to the fact that the agricultural methods of the area are comparatively new, and large initial expenditures were necessary before the best soils could be fitted for agricultural purposes. Many of these mortgages have been incurred for drainage and other permanent improvements.

A large proportion of the farms are operated by the owners personally. Some of the larger holdings are operated by salaried overseers. According to the census of 1900, 81.3 per cent of the farms in Bay County are operated by the owners, 77.6 per cent in Saginaw County, and 77.3 per cent in Tuscola County. Of the total number of acres in farms, 66.5 per cent are improved in Bay County, 66.1 per cent in Saginaw County, and 67.8 in Tuscola County. About the same proportions hold for the part of Huron County included in the survey.

A certain cash sum per acre is usually paid for rented lands. This varies with the character of the soil and the uses to which it is to be put. Any of the better soils, when used for the general crops, rent for about $5 an acre, while if they are to be used for beet production they rent for $8 and sometimes as high as $10 an acre.

Not a great deal of the improved lands is for sale. The prices range from a nominal sum for the least desirable areas of the Miami sand and Miami fine sand to $50 or more an acre for the better types. Anywhere from $50 to $80 an acre is being asked for the Clyde loam, while for the Clyde sandy loam $50 an acre is considered a fair price. The best areas of the Miami sand and Miami fine sand sell for about $25 an acre. The price paid for any type is usually in direct proportion to its recognized value for the production of the crops now grown. Undeveloped lands can be had for $10 to $25 an acre, depending upon the type of soil and the conditions of drainage.

The farms of the area are generally small, but there are occasional holdings of 640 acres or more in one body. The larger holdings are sometimes operated as a whole by the owner, or they may be subdivided and tenanted. The census of 1900 gives the average size of farms in Bay County is 61.5 acres, in Saginaw County as 74.8 acres, and in Tuscola County as 80.8 acres. As operated, the general run of farms is from 40 to 160 acres each.

In the general farming line the question of labor is not of serious concern, as the greater part of the work is done by the farmer and his family, except during harvest season, when considerable extra help is needed. By cooperating among themselves the farmers can do most of the harvesting without much outside help. Temporary help is drawn largely from the near-by cities, and during harvest season from outside points. Regular farm hands are paid about the rates usual throughout the North, namely, from $18 to $25 a month with board. For transient help $1 a day is paid, except during harvest season, when the rates are considerably higher.

The sugar-beet industry requires a great deal of hand labor, but as yet the growers have had little trouble in getting all they needed. Boys, girls, and women are largely employed in thinning and weeding the crop. Their pay ranges from 75 cents to $1 a day.

During the past fifteen years a great many Poles have come into the Saginaw Valley. A number of these, as already mentioned, have rented or bought farms, while the remainder have joined the laboring class, of which they at present form the majority. They are usually thorough, and on the whole make very satisfactory laborers.

The principal agricultural products are corn, oats, wheat, hay, sugar beets, beans, and potatoes. There are many other crops of relatively less importance, among which may be mentioned barley, rye, buckwheat, cucumbers, beans, cabbage, cauliflower, tomatoes, and onions, and among the fruits grapes, apples, and pears. Dairying is practiced on a small scale by a large number of farmers and quite extensively by a few others. Some attention is also given to beef cattle, sheep, and horses.

Except on the sandier soils, the corn yields are usually good, but in some seasons the crop is injured by wet or cold spells during the growing season, and occasionally by early fall frosts, which not only reduce the yields, but injure the quality of the corn. When badly bitten by frost the corn is not considered good for seed purposes, and much of the fodder is allowed to go to waste. According to the census of 1900 the average yield of corn for Bay County was 25.8 bushels per acre, for Saginaw County 30.8 bushels, and for Tuscola County 30.5 bushels. These averages would be much higher were not so much corn planted on the sandier types of soil.

The wheat crop sometimes is seriously injured by rust, and on account of this disease the acreage in this crop has fallen off for the past few years. The oats crop is also injured to some extent by rust and smut. The other small grains do well. The heavier soils of the area are well adapted to wheat and oats, and the yields are ordinarily very good where the soil is properly drained and prepared.

All of the hays grown are of excellent quality, and the yields are good.

Nearly all of the vegetables grown do well and find a ready market. There is undoubtedly a need for further development in the line of trucking. Potatoes do well and usually command good prices.

The fruits grown are generally for home use and for local markets. The quality and yields are good. The production of fruit for market purposes should be taken up in a more systematic way, so that a ready and reliable market could be built up for all the fruits produced.

The sugar-beet crop has passed the experimental stage and has proved well adapted to the climate and certain soil types of the area. The quality of the beets is generally very good and the yields from indifferent to good, depending largely upon physical conditions of the soil, the type of soil used, and the care and skill used in the cultivation of the crop. The factories have not yet reached the stage where they can pick the best growers, the result being that many farmers not qualified to grow good beets, and as many others with undesirable soils, are given contracts in order to get a running supply. Many of these farmers get light yields and are naturally dissatisfied with the returns. They do a great deal toward discouraging other farmers from growing beets. In so far as possible the factories should induce only those farmers to enter upon the cultivation of this crop who are prepared to do the intensive work necessary to success and who have the types of soil best adapted to the production of large yields of beets of high sugar content.

As the agricultural developments of the area are comparatively new, not a great deal of attention has been paid to special adaptation of soils to crops. The greater number of farmers have followed the customary system of general farming regardless of the soils used. As a result, soils peculiarly adapted to certain crops are not being used to any extent, if at all, for those crops. However, the tendency now is toward specialized farming, in which at least broad soil adaptations are recognized. So, instead of finding certain crops growing indiscriminately on all soil types, they will be found to be confined largely to a single soil type or to a group of soil types possessing some characteristics in common. An instance of this kind is seen in chicory production. The Clyde sand and the Saginaw sandy loam are the principal chicory soils; but this crop is grown to a more limited extent on other sandy types, though very rarely on the heavy soils. The principal sugar-beet soil is the

Clyde loam, which has been found to give the most satisfactory results. Local markets are a large determining factor in growing truck crops. In the vicinity of Bay City nearly all of the trucking is done on the Clyde sand and the Saginaw sandy loam, while near Saginaw the Clyde loam and the Clyde clay are now largely used.

The area is provided with an extensive system of railroads, along which are stations and sidings at convenient intervals. Some of these roads are main lines, affording quick service to all outside points, while the others are branch lines centering at Bay City and Saginaw. The area also has river and lake transportation facilities, but these are not used very extensively for handling agricultural products. There are public highways on nearly every section line, and in places on half-section lines. Some of these are hardly passable in wet seasons, but when dry they are fairly good. All of the principal roads leading out of Bay City have been macadamized for several miles. In Tuscola County many of the roads have been graveled and thus greatly improved. Saginaw County has done very little in the line of permanent road improvements.

Saginaw and Bay City afford good local markets for much of the agricultural products of the area. Large amounts of truck are consumed in these two places. The bean crop goes to outside markets, while the cucumbers are temporarily taken care of by salting stations located in several of the towns throughout the area. Local flour mills consume large quantities of wheat. With the exception of a small amount of chicory grown in the vicinity of Gagetown, which is used by a factory to the east of the area, the chicory crop is handled by a branch factory at Bay City. The beet crop is consumed by factories in Bay City, Saginaw, Caro, and Sebewaing. There are four factories in Bay City and one in each of the other places named. All outside markets are easily reached from the area.

SOIL SURVEY OF THE ALMA AREA, MICHIGAN.

By W. EDWARD HEARN and A. M. GRIFFEN.

LOCATION AND BOUNDARIES OF THE AREA.

The Alma area lies within Gratiot County, which is situated in the south-central part of the State of Michigan, about midway between Lake Michigan and Lake Huron and about 40 miles north of Lansing. The present survey includes the northern half of the county, comprising the townships of Wheeler, Bethany, Pine River, Seville, Sumner, Arcada, Emerson, and Lafayette. The area is rectangular in form, having a length of 24 miles east and west and a width of 12

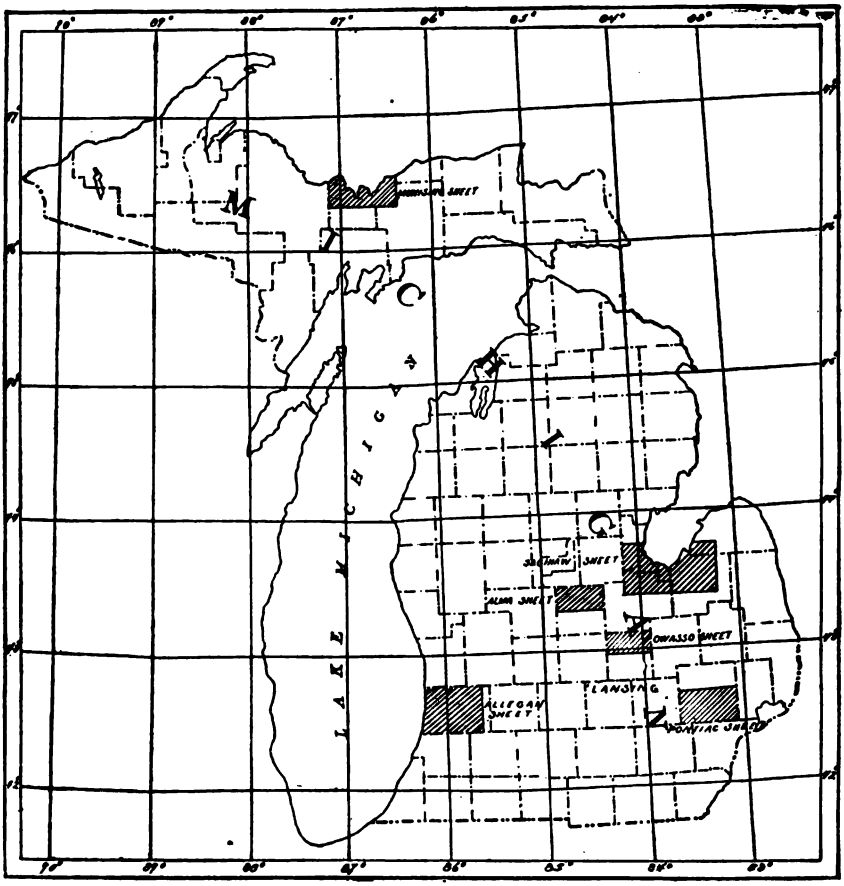

FIG. 26.—Sketch map showing location of the Alma area, Michigan.

miles north and south, and contains 180,800 acres, or approximately 282 square miles.

Gratiot County is bounded on the north by Midland and Isabella counties, on the east by Saginaw County, on the south by Clinton County, and on the west by Montcalm County. It is traversed by the Pere Marquette and Ann Arbor railroads. Ithaca, the county seat, has a population of about 2,000, while Alma and St. Louis are somewhat larger.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Gratiot County was formed about 1855. Seven townships were organized at that time by act of the State legislature, and several other townships formerly attached to the counties of Clinton and Saginaw have since been made a part of Gratiot County.

William McOmber, probably the first white man to settle permanently in what is now Gratiot County, came in 1832. He was an agent for the Northwestern Fur Company, and carried on a considerable trade with the Indians. These were nearly all of the Chippewa tribe, and being of a peaceable nature no serious trouble arose between them and the white settlers. They soon moved to a reservation in Isabella County, which was ceded to them by the Government in 1856. The first locations of land were made in 1836, but no permanent settlements were effected until 1846. The first sawmill to begin operations in the county was built in 1855, and was followed by the erection of frame houses and substantial buildings of every character. For a long time the only road of any description through the county was known as the "old Indian trail," which extended from Maple Rapids to the Lutheran mission above St. Louis. Saginaw and Maple Rapids were the chief trading points for the Gratiot County people. Pine River furnished a means of transportation both for supplies and lumber.

The early inhabitants came largely from New York State, although there were a number from New England, New Jersey, Pennsylvania, and Ohio, and some from Canada. In the early days this region was known as "Starving Gratiot," and many settlers became discouraged with their venture, but the county soon proved itself one of the best in the State. Upon their arrival the settlers found the whole county densely covered with a magnificent growth of pine, maple, beech, oak, ash, basswood, and elm, with some butternut, hickory, and hemlock. Some of the swamps, especially those around Riverdale, supported forests of white cedar, while most of the Muck areas were covered with tamarack. The pine timber abounded chiefly in the northern part of the county, and was confined to the more sandy soils; the beech and maple forests were usually characteristic of the sandy loams, while the white elm, black ash, oak, hickory, and maple were indicative of heavier soils, and were found most abundantly on the heavy loam soil in the eastern and central parts of the county.

The first settlements were made on ridges and knolls, as all of the area mapped as Clyde loam was at that time a veritable swamp, though since the natural drainage ways have been opened up and new ditches cut through the area it has become one of the most productive soils in this section of the State. During the summer and fall of 1855 and the spring of 1856 the population rapidly increased, large fields had been cleared, and improvements were seen on every hand. The timber, however, was of little value until the advent of railroads. The Saginaw Valley and St. Louis Railroad was first built from Saginaw to St. Louis, and later extended to Grand Rapids and the name changed to the Pere Marquette. The Toledo, Ann Arbor and North Michigan Railroad was built about 1883, and is now known as the Ann Arbor. The railroads have acted as a great stimulus in advancing the industries of this section.

Since the settlement of the area corn, wheat, oats, and grass have been the principal products. Until recently wheat was one of the most important crops, large yields being obtained, but the acreage devoted to this crop has decreased within the last few years, owing to the ravages of the Hessian fly, to dry seasons, and to extreme cold winters. Sheep and cattle raising have been rather important factors in the development of the county's wealth. In the early days when crops were light the farmers had a fair income from their timber land. The lumber industry was of great importance for a few years during the settlement of the area.

The growing of sugar beets on a commercial scale began in 1899. Some few patches had been grown previously as an experiment, and the success of these aroused confidence and enthusiasm in this new branch of agriculture. The summer of 1899 was unfavorable for beets, but the second year the beets made a good growth, and the sugar content was high. This crop proved to the growers that the soil and climate were suitable for the production of sugar beets and to-day they are one of the money crops of the area.

CLIMATE.

The following table, compiled from Weather Bureau records, shows the average monthly and annual temperature and precipitation at Alma for a period of about seventeen years. The coldest months are December, January, and February, and the minimum temperature recorded within five years was —24° F. The warmest months are July and August, and the maximum temperature has not exceeded 98° F. The winters, as the records show, are very cold. The summers are cool and pleasant, with a high percentage of sunshiny days. The last two summers have been somewhat colder and wetter than the three just preceding.

Normal monthly and annual temperature and precipitation.

Month.	Alma.		Month.	Alma.	
	Temperature.	Precipitation.		Temperature.	Precipitation.
	° *F.*	*Inches.*		° *F.*	*Inches.*
January	21.6	2.43	August	67.2	2.44
February	20.8	1.62	September	60.8	3.14
March	29.3	2.44	October	48.6	2.58
April	44.9	2.25	November	37.7	2.94
May	54.9	3.19	December	27.0	2.35
June	66.6	3.13	Year	45.7	31.52
July	70.1	3.01			

In the accompanying table are given the dates of the last killing frost in spring and the first in fall. The average dates are May 9 and September 25. This gives a growing season of about 149 days for the tenderest crops.

Dates of first and last killing frosts.

Year.	Alma.		Year.	Alma.	
	First in fall.	Last in spring.		First in fall.	Last in spring.
1898	Sept. 11	May 13	1902	Oct. 10	May 14
1899	Sept. 14	Apr. 16	1903	Oct. 18	May 4
1900	Oct. 20	May 22	Average	Sept. 25	May 9
1901	Sept. 18	May 15			

PHYSIOGRAPHY AND GEOLOGY.

The topography of the Gratiot County area is that of a region where glacial action has completely effaced preglacial features. The area comprises two main physiographic divisions. The larger of these, which occupies a little more than one-half of the area, consists of a series of glacial moraines extending in a general north and south direction. The continuous ridge extending from Ithaca through St. Louis is the most easterly of these. To the westward are found others, usually separated by ancient drainage channels, which, consisting of glacial material reworked by streams, give rise to more sandy soils than are found in the uplands.

The surface of the morainic country is usually rolling. In some localities a "kame and kettle" topography is typically developed, and the surface is so very rough and broken that tillage is almost impossible. Gravel deposits occur under many of these hills, but they are usually buried so deeply beneath the till that they do not affect the soil. In many parts of the rolling country sand deposits are found, and in the western part of the area a higher moraine extends almost across Seville and Sumner townships. This contains more sand and gravel than the other moraines, and in places develops into quite extensive sand plains. There are numerous small depressions and sags upon the moraines which have no drainage outlets, and it is in these small depressions that the muck areas occur.

East of the ridge running north from Ithaca the surface consists entirely of lacustrine sediments deposited in the ancient Lake Saginaw, the first of a succession of glacial lakes formed between the ice front and the moraine. These sediments give rise to the Clyde loam, and, as might be expected, are very uniform, the only variation of note consisting of sandy deposits representing the shoals and shore lines of the old lake, which have formed small areas of sand and sandy loam. With the exception of these low ridges there are no marked topographic features in this part of the area surveyed.

Excepting the southeastern portion of Arcada Township, and other local areas lying principally in the old drainage channels, the western part of the Gratiot County area is well drained. The general rolling character of the country gives rise to many small streams tributary to the Pine River. This river enters the area near the northwest corner and flowing south near the western boundary leaves the area below Riverdale. About 2 miles south of this point it reenters the area, runs southeast to a point near the southern boundary, then curves northeast around the end of the western moraine, skirting its base for several miles, then pierces the eastern moraines by a narrow valley, and continues its northeast course out of the area. Although it is not a swift stream it has sufficient fall to furnish power to several flour mills along its course. In the flat eastern portion of the area the drainage problem is a more serious one. Goose and Beaver creeks and the Bad River furnish outlets, but the streams are sluggish, with few tributaries, and an extensive system of ditching is necessary to drain the land between them.

The last ice advance which covered Gratiot County is known as the Wisconsin, and the present moraines are a part of those left by this glaciation. It is likely that a portion of the entire drift mass was formed by earlier advances of the ice, but how much is not known. Many large and small bowlders of granitic rock and some limestone are found scattered over the entire area.

The thickness of the glacial drift varies considerably in different parts of the area. At Alma it is 500 feet, at Ithaca 350 feet, and at St. Louis about 300 feet thick, and a well boring made about 3 miles northeast of St. Louis is reported to have struck rock at 80 feet. In the vicinity of Alma and St. Louis there are many small flowing wells and a few of considerable size. Water is usually obtained from these at a depth of about 60 feet. Well water is easily found in all parts of the area. In the upland portion the wells vary from 20 to 80 feet in depth and in the lowland from 6 to 15 feet.

Gratiot County lies nearly in the center of the great Michigan coal basin. It is not likely, however, that any extensive coal deposits will be found. The rock underlying the drift is a carboniferous sandstone, but does not outcrop within the area. Small deposits of shell marl are found in some of the muck areas, but none of commercial importance. The glacial clays furnish a suitable material for the manufacture of tile, and there are three factories within the area.[a]

SOILS.

Eight distinct types of soil, exclusive of Meadow, were recognized and mapped in the Alma area. The area and proportionate extent of each of these types are shown in the following table:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Clyde loam	59,776	33.1	Meadow	6,592	3.6
Miami fine sandy loam	34,432	19.0	Miami clay loam	6,144	3.4
Miami sand	33,472	18.5	Miami gravelly sand	5,504	3.0
Clyde sandy loam	13,696	7.6	Total	180,800	
Muck	10,816	5.9			
Clyde sand	10,368	5.7			

CLYDE LOAM.

The surface soil of the Clyde loam consists of a black or drab-colored loam to a depth of 6 to 10 inches. It is locally spoken of as the "clay land." This type contains quite a large amount of organic matter, and this, together with the relatively high percentage of fine and very fine sand, makes of the greater part a mellow, loamy soil. Some slight variations in texture occur; in a few places the surface soil may be a clay loam, while in other areas spots with a sandy covering are sometimes encountered, but the agricultural value seems to be about the same for all areas. In the wetter and lower-lying areas the soil cracks open when dry and has the appearance of a stiff clay soil.

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[a] The authors wish to acknowledge their indebtedness to Prof. Charles A. Davis, of Ann Arbor, Mich., for information given in this chapter on the geology of the Alma area.

The subsoil, to a depth of 36 inches, is either a blue, yellowish, or mottled clay or clay loam, stiff and rather tenacious. Strata of sandy material are usually found in the subsoil between 18 and 24 inches, or again the clay may grade into a sticky, sandy clay at 30 inches. The clay is plastic when wet, but hard and crumbly when dry, cracking open in road cuts and ditch banks, as well as on the surface. Underlying the larger areas of Clyde loam a hardpan, composed chiefly of consolidated clay, is found at from 4 to 10 feet beneath the surface. This is usually quite impervious to water, and interferes to some extent with the drainage of this soil.

The Clyde loam is the most extensive soil type in the area. It occurs most typically developed in broad, extended areas in the eastern half of the survey, covering the greater part of Emerson and Lafayette townships and large areas in Wheeler and Bethany townships. Many smaller areas and isolated spots of this soil are scattered over the entire area. Large areas of soil in the adjoining counties to the north, east, and south are similar to this type.

The surface features are generally level throughout, with scarcely any great difference in elevation even in the larger areas. In the vicinity of some of the natural drains the surface is slightly undulating. Some areas of this soil are found occupying depressions and swales interspersed through the other types.

Owing to its flat surface and the rather impervious subsoil, the Clyde loam possesses poor natural drainage. The best results are obtained from this soil where it has been artificially drained. When the county was first settled all the larger areas were in a swampy condition, but by opening up the natural drainage outlets and digging large open ditches these productive areas have been reclaimed. Large open ditches, with smaller laterals and tile drains leading into these, are essential for the thorough drainage of this soil, and many tile drains are now being laid.

Sometimes in the spring these level low-lying areas are covered with water for several days at a time, and the planting of crops is often considerably retarded on account of the wet condition of the soil.

Several tile factories are in operation in the area, and tiling can be secured at reasonable prices. Factories for its manufacture are located at Ithaca, northwest of Ithaca, and west of St. Louis. Most of the tile drains are laid 8 rods apart, and this makes the cost about $15 an acre. The proper drainage of the Clyde loam areas insures a more uniform distribution of the soil moisture, better yields and better quality of crops, and also tends to promote the health of the community.

The material from which this soil type is derived consists almost entirely of lacustrine sediments deposited in the ancient Lake Saginaw. The clay was deposited in rather quiet water, and the sand of different grades found in this soil is probably the coarser material brought in by the streams and deposited over the floor of the lake during periods of high water.

This type was formerly covered with a heavy growth of white elm, black ash, hickory, oak, maple, and other hardwoods. In some places quite a large amount of vegetable mold is found on the surface, due to the accumulation of the decayed foliage from this growth, giving the soil in places an oily consistency. Some tests have been made with lime on the Clyde loam, and beneficial results were secured. It will doubtless make the soil looser and serve to correct its acidity. In some of the wetter areas the soil is cold and sour, and the sweetening of such areas would cause an increase in the yield of crops.

The Clyde loam is an easily tilled soil if cultivated at the proper time, but if worked either too wet or too dry it breaks up into lumps and is apt to remain in a rough condition for the entire season. When the county was first settled this type of land was considered worthless, but since it has been drained and cleared it is the most productive soil in the area surveyed. The greater part is now under cultivation, and it will be only a short time before the entire area of the type is converted into productive fields.

This soil is especially adapted to the production of sugar beets, corn, oats, wheat, and hay. The beets have no trouble in penetrating the subsoil, and a large, long, smooth beet is the result. It is an excellent all-around grain soil. Corn yields in favorable seasons from 30 to 50 bushels per acre; wheat, from 20 to 30 bushels; oats, 35 to 70 bushels; hay, from 1½ to 3 tons; sugar beets, from 8 to 18 tons; beans, 18 to 25 bushels. Potatoes, barley, cabbages, buckwheat, pumpkins, and garden vegetables do well. Apples, cherries, plums, and pears also thrive. Grapes give fair returns on the better drained areas, while the same soil in the lake zone is peculiarly adapted to their production.

The Clyde loam land, with improvements, ranges in price from $40 to $80 an acre, depending on location and distance from railroads, while some unimproved land of this type can be bought at from $20 to $25 an acre.

The table following shows the results of mechanical analyses of typical samples of the Clyde loam.

Mechanical analyses of Clyde loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11222	5 miles NE. of Ithaca.	Black loam, 0 to 8 inches.	1.5	4.4	8.0	25.7	15.7	27.1	17.5
11446	3 miles NW. of Breckenridge.	Black loam, 0 to 7 inches.	1.1	4.6	9.3	26.2	11.7	25.7	21.3
11444	1 mile NW. of Rathbone.	Black loam, 0 to 9 inches.	1.0	5.4	8.8	22.8	12.5	27.0	21.9
11223	Subsoil of 11222	Mottled loam, 8 to 36 inches.	1.5	4.6	8.1	23.9	16.0	25.6	20.2
11445	Subsoil of 11444	Stiff clay loam, 9 to 36 inches.	1.0	4.5	8.2	21.7	11.7	23.2	29.0
11447	Subsoil of 11446	Yellow clay loam, 7 to 36 inches.	1.1	3.8	7.7	22.1	9.6	23.9	31.6

The following samples contain more than one-half per cent of calcium carbonate ($CaCO_3$): No. 11223, 7.4 per cent; No. 11445, 2 per cent; No. 11446, 0.54 per cent.

MIAMI FINE SANDY LOAM.

The surface soil of the Miami fine sandy loam, to a depth of 6 to 18 inches, is a light-brown medium to fine sandy loam. In many places the amount of silty material found in this soil is particularly noticeable. Gravel and cobblestones are usually present in the soil, but not in sufficient quantities to interfere with cultivation. Some of these cobblestones have been picked up and piled in heaps. Occasionally large granitic and schistose erratics are seen on the surface. Many areas, however, are practically free from stones and gravel.

The subsoil, to a depth of 36 inches, is a brown or chocolate-colored loam or clay loam, increasing in clay content with depth. In a very few small spots this clay loam is underlain by coarse sand and gravel at from 4 to 6 feet.

In addition to the typical areas of the Miami fine sandy loam there occur some variations of importance. In the northwestern part of the area surveyed the surface soil is deeper and somewhat more sandy than the areas found elsewhere. This is probably due to its topographic position, and also to its connection with the Miami sand. Pockets of sand are not uncommon in the Miami fine sandy loam, while many spots of silty and claylike material are observed throughout some areas of this soil. There are, moreover, many small spots of Meadow and kettle holes of Muck scattered here and there, which are too small to be represented on the soil map. These variations, caused largely by topography, give this soil a somewhat varied texture and a rather spotted appearance.

The Miami fine sandy loam is confined to the central and western parts of the area surveyed, except for a few narrow strips in Lafayette Township. It occurs in large bodies of irregular outline, usually running in a north and south direction, in Pine River, Seville, Sumner, and Arcada townships, and on the west side of Emerson and Bethany townships.

The surface features of this soil give the type a more diversified character than that possessed by the other soil types in the area. It occupies morainic topography, consisting of rolling uplands, knolls, sharp ridges, and gently rolling to level areas. A "kame and kettle" topography is markedly distinct in the area north of Ithaca, and also in Seville Township. In the vicinity of Elwell and in a few other localities the surface is practically level to gently rolling.

The Miami fine sandy loam for the most part possesses excellent natural surface drainage, due to the position it occupies, combined with the rather loose character of the soil. However, there are a number of kettle holes here and there, of very small extent, which are wet and swampy, and which can not be drained at a reasonable expense. In the more level and gently rolling areas open ditches are sometimes seen. These are quite serviceable, as the clay loam subsoil stands up well in the banks. In a few areas tile drains have been put in and good results are obtained.

This soil type owes its origin to the weathering of glacial moraines. The material as left here by the glacier probably contained a considerably greater amount of clay than at present, but the fine material has been in a great measure carried away in suspension, leaving a light, loose, sandy loam soil. The surface has been eroded to a marked degree, and wide variations in the texture of this soil are the results of this unequal erosion.

All the crops common to the area are grown upon the Miami fine sandy loam. Those that give best results are corn, potatoes, oats, hay, beans, fruits, and berries. The surface of the soil in some places is too uneven and the texture too varied for the profitable production of sugar beets. The more level and gently rolling areas, with a uniform textured soil, produce good yields of beets, and such areas are recommended for this crop. Beets average from 7 to 12 tons per acre; hay, from 1 to 2 tons; potatoes, 60 to 150 bushels; corn, 25 to 40 bushels; while oats, wheat, barley, rye, and clover do fairly well. Beans average from 12 to 15 bushels. Some buckwheat is also grown. Apples do very well, and also plums, pears, and cherries.

The following table shows the results of mechanical analyses of the fine earth of both soil and subsoil of this type:

Mechanical analyses of Miami fine sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11436	3¼ miles N. of Elwell.	Brown fine sandy loam, 0 to 14 inches.	1.1	7.0	11.5	33.3	13.6	21.9	11.1
11216	3 miles N. of Ithaca.	Fine sandy loam, 0 to 12 inches.	1.7	6.5	9.9	26.1	15.1	29.0	11.7
11437	Subsoil of 11436	Brown loam, 14 to 36 inches.	1.5	5.0	9.8	26.2	10.3	28.1	18.6
11217	Subsoil of 11216	Brown clay loam, 12 to 36 inches.	1.2	2.8	4.8	15.3	13.8	32.7	29.3

MIAMI SAND.

The Miami sand consists of a fine to medium sand to a depth of 5 to 8 inches. It varies considerably in color, but the largest areas of it are usually of a light-brown or gray color. The more rolling areas of this type possess only a small percentage of organic matter, while the gently rolling and level bodies contain considerable in the surface soil, this being especially the case in the areas adjoining the Clyde sand. The subsoil, to a depth of 36 inches or more, is a yellow, or sometimes a reddish-yellow or gray, medium to fine sand, loose and incoherent. Occasionally a few gravel fragments are found in both the soil and subsoil, particularly in the northwestern corner of the survey, and also adjacent to the Miami gravelly sand areas. This sand is sometimes underlain at from 4 to 6 feet by clay, while small areas of it are underlain by gravel beds.

The largest areas of the Miami sand are found in Sumner, Wheeler, and Seville townships, and in strips along Pine River. Many irregular areas and isolated spots are scattered over the area. It frequently happens that this soil is interspersed throughout the Miami fine sandy loam areas, and this is especially noticeable in Seville Township.

The surface features of this soil type show a much diversified character. The main areas of it, however, have a rolling surface, with ridges, knolls, and intervening gently rolling areas, but in the northeastern corner of Wheeler Township the surface is level to undulating. The most broken topography of the Miami sand is observed in the northwestern part of the area, where it occupies the knolls and ridges which attain the highest altitude in the area. Along Pine

River this soil varies from a gently rolling to a somewhat hilly surface.

The loose, open texture of both the soil and subsoil, together with the rolling character of the country, insures excellent natural drainage for the greater part of this type. A few of the more level areas, in Wheeler Township and some other localities, should be artificially drained. This would give a warmer soil and cause it to be suited to a greater variety of crops. Open ditches would be of considerable service, even in this sand.

The Miami sand owes its origin to glacial wash sand. This was washed from the glacier during times of swift waters. It has been modified in a great many places, however, by stream action, and along Pine River it has been deposited as deltas. In the eastern part of the area it is found in ridges, which at one time were likely shore lines or shoal water bars, the sand being drifted up by the waves or brought into the former lake by the incoming currents.

This soil is well suited to the production of small fruits, berries, potatoes, and garden truck, and will probably grow good peaches. The growing of leguminous crops to supply this sand with a larger amount of organic matter, as well as the use of coarse manures, is highly recommended. This soil would be considerably improved by applying large amounts of muck to it.

The crops commonly grown upon this type are corn, barley, potatoes, oats, buckwheat, berries, hay and some fruit. A few sugar beets are grown, but this crop should be confined to the heavier soils. A low tonnage is usually obtained, though the beets contain a high percentage of sugar. Grain crops generally give a low yield, although some few areas, which have been heavily manured and properly cultivated, produce good crops in favorable seasons. The soil is too light textured for general farming on an extensive scale. Potatoes, barley, and corn give fairly good yields.

The Miami sand was originally heavily forested with white pine, but now only a few beeches and maples are seen, while the largest forested areas are covered with a dense growth of white poplar brush. There are large bodies of this type that are undeveloped, and this condition is especially noticeable in the northeastern and northwestern corners of the area and also in Sumner Township. The Miami sand sells at from $10 to $35 an acre.

The following table shows the results of mechanical analyses of the fine earth of the Miami sand:

Mechanical analyses of Miami sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11218	1½ miles NE. of Sumner.	Gray sand, 0 to 5 inches..	1.2	12.6	36.9	41.8	3.2	2.3	1.9
11440	5 miles NE. of Breckenridge.	Brown sand, 0 to 6 inches.	1.0	8.2	22.4	56.3	4.1	5.6	2.0
11441	Subsoil of 11440......	Yellow sand, 6 to 36 inches	.9	7.7	24.0	60.9	3.9	2.1	.5
11219	Subsoil of 11218......	Yellow sand, 5 to 36 inches	.9	6.6	37.4	49.0	1.9	1.6	2.6

MIAMI CLAY LOAM.

The Miami clay loam, to a depth of 6 to 9 inches, consists of a light-brown, gray, or ashy colored loam. In many places, however, the surface soil contains a high percentage of very fine sand, while in other localities a very heavy loam is found, being composed almost entirely of silt and clay. The surface soil of this type before reaching the typical underlying subsoil grades into a layer of whitish silt from 1 to 4 inches in thickness. The subsoil is a brown or chocolate-colored clay loam or clay to a depth of 36 inches or more, increasing in clay content with depth. It is rather stiff, very plastic when wet, cracking open and becoming hard and crumbly when dry, and breaks up into lumps having a somewhat granular structure.

The Miami clay loam is most typically developed in the vicinity of Alma, in the northern part of Arcada Township, and in the southern part of Pine River Township; but a few areas and isolated spots are also found scattered across the western and northern parts of the area. The type occupies rolling ridges, knolls, and gently rolling areas. Sometimes it occurs as a level area in the Miami fine sandy loam, and it is closely allied with that type both in respect to origin and topographic features.

The greater part of the Miami clay loam possesses good natural surface drainage, but the structure of the subsoil is such that tile drains prove beneficial. Underdrainage regulates the soil moisture, aerates the soil, and carries off the excess of rain water that would otherwise remain for a long time in the subsoil. As a rule this soil is wet for several weeks in spring from the melting snow, and a system of underdrains would materially shorten this period, during which the soil can not be worked. Quite a large proportion of the

Miami clay loam has been tile drained already, and actual experience has shown the practice to be profitable in many ways.

The Miami clay loam is of glacial origin, being the true till left here in the form of moraines by the retreating ice sheet. In some places this formation does not appear to have undergone any great degree of erosion, while in others it has been subjected to considerable, thus giving a very rolling surface. In a few places a large part of the clay has been removed in suspension by the rain waters.

Considerable care should be exercised in regard to the time of plowing and the manner of pulverizing this soil in the spring, in order that cultivation may be most easily carried on and that crops may give the best yields. If plowed and harrowed at the proper time, it is an easily tilled soil; otherwise the soil breaks up in clods, and is liable to remain for the entire season in a coarse lumpy condition—a feature very objectionable in the cultivation of sugar beets and other crops requiring intensive methods.

The Miami clay loam is considered a fairly productive soil and one readily improved by manure. The crops grown upon it at present, judging by the yields obtained, seem to be well suited to this soil. The well-improved land of this type, which has been in part tile drained, and which has been cropped in a regular rotation, produces as follows: Corn, 40 to 50 bushels per acre; oats, 30 to 60 bushels; timothy hay, 2 tons; clover hay, 1½ tons, and sugar beets, from 8 to 15 tons per acre. Beans and potatoes do very well on this soil. The success of the few small apple orchards observed on this type would indicate that this industry could be profitably extended on a commercial scale. Pears, plums, and cherries also do fairly well.

The Miami clay loam occupies a unique position as regards town and railroad facilities, as the greater part of it lies within 2 miles of a town. It is held at from $35 to $100 an acre.

The following table shows the results of mechanical analyses of typical samples of the Miami clay loam:

Mechanical analyses of Miami clay loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11448	1 mile SE. of Alma	Brown loam, 0 to 6 inches.	1.8	4.6	7.9	19.8	10.3	35.0	20.0
11450	1 mile W. of Alma	Brown loam, 0 to 9 inches.	1.7	4.2	7.9	19.2	13.7	27.4	25.8
11451	Subsoil of 11450	Brown clay loam, 9 to 36 inches.	.0	3.9	4.7	13.9	12.3	30.7	34.8
11449	Subsoil of 11448	Brown clay, 6 to 36 inches.	.7	2.6	4.2	12.5	6.0	29.0	44.9

CLYDE SANDY LOAM.

The surface soil of the Clyde sandy loam consists of a black or brown medium to fine sandy loam, with a depth of from 8 to 15 inches. A few gravel and cobblestones are usually present on the surface and mixed throughout the subsoil. The subsoil is a yellow, sticky sandy loam or a blue clay loam grading into a rather stiff clay. There are many variations of this soil type, but since the type occupies only very limited areas, these variations could not be separated or shown on the soil map. In some localities the soil is a heavy sandy loam which grades into a blue clay. Again, the surface soil may be a black or brown loamy sand for a depth of 18 inches, and underlain by a light, loose sandy loam or sand. As compared with the same type in the Saginaw area, the soil in the Alma area is somewhat finer, and the percentage of clay, especially in the subsoil, is higher. The Clyde sandy loam is often spoken of as the "maple and beech ridge" land.

This type occurs in peculiarly shaped areas and spots scattered irregularly throughout the townships of Emerson, Lafayette, Wheeler, and Bethany, where it is associated with the Clyde loam. Several smaller detached areas are also found in other parts of the survey. These are commonly seen as depressions or swales in the morainic topography. The type has similar surface features throughout, in that it occupies the gently rolling and level areas. It is sometimes found in the form of a slightly elevated ridge or knoll. Owing to the rather open texture of the soil, the type has fairly good natural drainage. The level areas and swales in some places need artificial drainage, while some of the level areas where the blue clay comes near the surface would be improved by tile drains, and these have been laid in some instances.

The Clyde sandy loam consists of glacial material which has been reworked and redeposited in many instances by stream or wave action. Where it occurs in the form of low ridges it probably represents the low beach lines of the old Lake Saginaw. Since its deposition it has accumulated within the surface soil a considerable amount of organic matter, and a black sandy loam of excellent tilth has resulted.

This is an easily tilled soil, and it is also fairly productive. It seems to be best suited to the production of potatoes, beans, and corn, although sugar beets, oats, wheat, and many other crops can be profitably grown. Beans mature more quickly on this type than on the heavier soils, and are less liable to damage by early frosts. At present corn yields from 25 to 40 bushels per acre; oats, 25 to 45 bushels; sugar beets, 7 to 14 tons; hay, from 1 to 2 tons; potatoes, from 80 to 150 bushels, and beans, from 15 to 25 bushels per acre.

Wheat, barley, and clover do fairly well, while apples, cherries, and plums can be easily grown. Berries and garden vegetables are successfully grown in a limited way, and this industry should be extended.

The following table shows the results of mechanical analyses of the fine earth of this soil:

Mechanical analyses of Clyde sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11220	6¼ miles NE. of Ithaca	Fine sandy loam, 0 to 8 inches.	1.9	5.6	9.6	49.4	15.4	13.1	5.0
11442	3 miles SE. of St. Louis.	Fine sandy loam, 0 to 12 inches.	1.3	6.6	12.5	32.4	18.4	23.0	5.8
11221	Subsoil of 11220	Fine sandy loam, 8 to 36 inches.	1.5	6.5	11.3	48.0	12.8	11.9	7.9
11443	Subsoil of 11442	Yellow sandy loam, 12 to 36 inches.	1.0	5.1	11.1	32.0	15.0	18.8	17.1

CLYDE SAND.

The surface soil of the Clyde sand has a depth of 8 to 12 inches, and consists of a black, loamy, medium to fine sand. It contains a large amount of organic matter, which gives it the black color and loamy characteristics. This type is closely associated with areas of Muck, and in some localities a thin covering of mucky soil is frequently found on the surface. In the northeastern part of the area there are bodies of this soil which are a brown to black loamy sand to a depth of 20 inches, resting upon a gray sand. The subsoil of this type is a gray or white medium sand, usually loose and incoherent, but in a few places containing a sufficient amount of clay to make it sticky, as it is commonly wet at 30 inches. Occasionally there are areas of this subsoil which are underlain by a rather coarse sand and fine gravel at 3 feet, while in some other places a blue clay is found at from 4 to 5 feet.

The largest bodies of the Clyde sand are found in the southwestern part of the area, in Arcada Township. Many smaller areas and isolated spots occur throughout the western and northern portions of the area surveyed, especially to the northeast of St. Louis.

Occupying low, flat areas, usually adjacent to the Muck, the surface of this soil is uniformly level. It also occurs as depressed areas along some of the small streams, and as swales in the Miami sand areas. By reason of its low, level position its natural drainage is not good, but the loose, open character of the soil and subsoil allow a free percolation of the rain waters. An exception occurs in Bethany and Wheeler townships where this soil has excellent drainage. In general the lower lying areas of the Clyde sand need to be artificially drained, as the permanent water table is generally reached at from 3 to 8 feet. These low areas can be drained in most cases by means of large open ditches.

The Clyde sand is very probably formed from glacial wash material, which has been modified in many cases by stream action. It has also been changed largely by the accumulating in its surface of a considerable quantity of organic matter.

Upon the Clyde sand are grown corn, oats, potatoes, hay, sugar beets, and cucumbers. Corn averages from 20 to 35 bushels; oats from 25 to 40 bushels, and hay from 1 to 2 tons per acre. Sugar beets are an excellent crop for the more elevated, well-drained areas of this soil, and often yield as much as 10 to 15 tons per acre. The greater part of the type, however, is not well suited to the production of beets. Corn and oats do exceedingly well in some areas. Timothy, potatoes, and beans give fairly good yields.

This soil is very easily tilled, and the moisture conditions are quite favorable for the greater part of the year. It is probably best suited to corn, oats, potatoes, cabbages, melons, and cucumbers. Celery can also be grown on this soil with a fair degree of success, although its cultivation has not been attempted on a commercial scale.

The following table shows the results of mechanical analyses of typical samples of the Clyde sand:

Mechanical analyses of Clyde sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11438	3 miles NW. of Alma.	Black medium to fine sand, 0 to 9 inches.	0.2	6.8	16.1	46.5	15.1	11.5	3.7
11214	2¼ miles W. of Ithaca.	Black sand, 0 to 10 inches.	.8	7.2	25.9	37.6	9.0	13.3	6.1
11439	Subsoil of 11438	Gray sand, 9 to 36 inches.	.6	8.6	19.0	48.3	12.5	7.7	2.9
11215	Subsoil of 11214	Gray sand, 10 to 36 inches.	.6	7.8	28.4	34.3	8.0	11.7	9.0

MUCK.

The Muck consists of organic matter, more or less thoroughly decomposed and mixed with a small percentage of clay. The Muck is usually from 3 to 10 feet deep, but areas have been mapped as Muck where the surface covering of vegetable matter was 12 inches or more in depth. These areas are generally underlain by either a blue clay or a white sand. Small spots of typical peat are found in some areas of this soil, but are not of sufficient extent to be shown on the map. In some localities there are evidences of marl deposits.

The largest bodies of Muck occur in very irregular outline to the northwest of Ithaca, in Arcada Township, scattered throughout Sumner Township, and in the northwestern part of Seville Township. Small areas and patches were also found in Pine River Township and in other parts of the area surveyed.

The Muck owes its origin to lack of sufficient drainage. In these depressed, inclosed, poorly drained areas flags, trees—such as cedar and tamarack—and other water-loving vegetation have grown and annually deposited their foliage. The accumulations of this decaying vegetation, together with a small amount of wind-blown and rain-washed fine mineral particles from the surrounding soil areas, constitute the true Muck soil. There are small spots, however, where this vegetation has not become so thoroughly decomposed, and areas of peat have resulted.

The Muck areas are uniformly flat, and natural surface drainage is almost lacking. However, the more extensive areas of this soil can be drained artificially by means of large open ditches, with smaller laterals or tile drains leading into these. The Muck stands up well in banks, and the blue clay also makes permanent walls, so that open ditches can be constructed with safety. There are some places where the Muck is underlain by sand, and judgment must be used as to the depth and location of these ditches. The water table is usually only a short distance beneath the surface. The small spots of Muck occurring in the depressions and kettle holes can not easily be drained, as in nearly all cases no natural outlet exists.

When the area was first settled the Muck was a veritable swamp, covered with a growth of cedar and tamarack, but to-day there remain only a few tamaracks, elms, flags, and coarse grasses. Many raspberries and blackberries were seen growing wild on the Muck. Only a small proportion of this soil is cultivated, while large bodies are pastured. Corn, oats, hay, and sugar beets have been grown to some extent. Hay yields from 1 to 1½ tons per acre. Sugar beets make a large tonnage at the expense of the sugar content. They have extra large tops and do not seem to ripen. Many farmers could use this Muck profitably by applying it in large quantities to the Miami sand where it occurs adjacent to the latter type, thus making the soil more loamy, more retentive of moisture, and richer in nitrogen. When these Muck areas have been artificially drained, reclaimed, and thoroughly cultivated for a few seasons they will be admirably adapted to celery, onions, and cabbages.

MIAMI GRAVELLY SAND.

The soil of the Miami gravelly sand varies from a fine to a coarse sand of brown color, with a depth of 10 inches and containing from 20 to 50 per cent of gravel and small stones. The gravel ranges in size from one-eighth of an inch to 3 inches in diameter, while the stones in some places may be as large as 5 inches in diameter. In a few places the interstitial soil is a dark-colored sandy loam, and areas of this phase are fairly productive. The subsoil, carrying from 30 to 40 per cent of gravel and small stones, is usually a yellow medium to coarse sand, but in some localities the texture is more nearly a sandy loam and the color a reddish shade. It is sometimes underlain by gravel. The typical coarse sand and gravel furnish an excellent grade of road ballast and are used for this purpose where conveniently located.

There are no extensive areas of this type, but the largest bodies occur in Sumner and Seville townships, along Pine River. Smaller spots and narrow ridges are found in several places in the northern part of the area surveyed, being closely allied to the Miami sand.

The surface features of this soil vary somewhat in different localities, but it generally occupies the level, rolling, and hummocky areas. In the vicinity of Riverdale the surface is practically level, while in other places it occurs as knolls and ridges. These ridges, representing former beach lines, are very pronounced near Breckenridge, where some of them rise from 5 to 10 feet above the surrounding soil types. These rolling areas and ridges have excellent surface drainage and, owing to the loose character of both the soil and subsoil, are apt to suffer seriously from drought. The level areas are fairly well drained, but more open ditches through these would prove beneficial.

The origin of the Miami gravelly sand may be traced to the outcrops of sand beds and ridges left here by the glacial ice. These beds have been exposed in many places and mingled with fine sand and silt. Probably some of this type has been reworked and redeposited by the swift currents of the river, as this gravel occurs in some places as terraces and again as former channels of the stream. The soil usually contains a small amount of organic matter.

This type is probably best adapted to barley, corn, beans, berries, and fruits. At present, however, barley, corn, beans, potatoes, hay, and cucumbers are the main products. The more loamy areas in favorable seasons produce fairly good yields of corn and beans. Cucumbers are grown to a considerable extent around Riverdale. The ridges and knolls are best suited to the production of fruit and should be used for this purpose.

The following table shows the results of mechanical analyses of the fine earth of a sample of the soil and subsoil of this type:

Mechanical analyses of Miami gravelly sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11224	8¼ miles W. of Ithaca.	Brown sand, 0 to 10 inches.	11.5	27.4	20.3	21.5	5.5	8.5	5.1
11225	Subsoil of 11224	Yellow coarse sand, 10 to 36 inches.	8.4	26.3	19.8	24.4	6.6	8.7	5.7

MEADOW.

The Meadow of the Alma area consists of a variety of material, varying in texture from a loam in depressions to a loose sandy or gravelly loam along the streams. Only small areas of Meadow are found, and these occur chiefly along Pine River in the southwestern part of the survey and to the northwest of Emerson Center. A few small spots and strips are shown elsewhere in the area surveyed.

The characteristic feature of the Meadow is its lack of adequate drainage. It occupies the low, flat areas subject to frequent overflows, which are commonly too wet for cultivation, parts of them being covered with water nearly all the year. Owing to its low position and proximity to the water level of the streams the Meadow areas can not be drained at any reasonable expense. Some of the spots mapped as Meadow were once lakes which have since been filled.

The chief use made of the land is for pasturage. In some places it is covered with a good growth of natural grass, while in others it is forested with elm, ash, and other hardwoods; and the wettest places support a luxuriant growth of flags and coarse marsh grass. Spots of Muck are of frequent occurrence throughout the areas of Meadow.

AGRICULTURAL METHODS.

The agricultural methods practiced in the Alma area vary considerably in different sections, according to the texture and position of the various soil types. The methods used by the majority of the farmers are fairly well suited to the conditions of the area, while others should change their practices considerably. The heavy soils require much more skillful management than the sandy ones, and are also adapted to different crops. A great diversity of crops is grown, owing both to the favorable climatic conditions and the large number of soil types. The specialization of crops that are adapted to certain soils has not been considered as seriously as it should be, and greater attention to this phase of agriculture would prove profitable to a number of farmers who now plant their crops at random on any kind of soil.

In the general farming operations of this region the use of commercial fertilizer has been almost unknown. Large quantities of barnyard manure are annually applied to the fields. The many cattle, hogs, and other live stock kept on each well-conducted farm produce considerable quantities of manure. In a number of cases this manure is not carefully saved, resulting in an annual loss frequently not appreciated by the farmers. The most careful husbanding of the manure is strongly recommended. During the last year or two some commercial fertilizer has been used by a number of the farmers in the growing of sugar beets. It seems to give the young beets a better start, making the plants more thrifty and hardy, and better able to withstand a wet season or a continued drought. The form of fertilizer most extensively used contains 2 per cent of nitrogen, 8 per cent of phosphoric acid, and 4 per cent of potash. From 150 to 300 pounds of this fertilizer is used to the acre. Some have experimented with 40 to 50 pounds of nitrate of soda. Lime can be recommended for the low-lying wet soils, which are apt to be more or less acid.

Corn, one of the most important crops, is grown on all the soils in the area. Level cultivation is usually practiced, this being done for the most part by sulky cultivators. Ridge cultivation is sometimes seen in the flat areas where the natural drainage features are not good. At maturity the stalks, with the ears, are cut, tied in bundles, and left standing in the field to complete the curing. Wheat is sown in the fall, while oats, barley, and rye are sown in the spring. With the last-mentioned crops timothy and clover are seeded. Seed drills and self-binders are commonly employed. Beans and potatoes are usually cultivated with horse cultivators, and very little hoeing is found necessary. The beans are given level cultivation, while the potatoes are usually grown in ridges. The beans when mature are cut by machinery or pulled by hand, hauled to the barn, and stacked until well cured, and then thrashed by machine as with wheat. The hay, which is chiefly timothy, is cut by horse mowers and raked in windrows. It is either stored in the barns or stacked in the fields. Buckwheat is grown to a limited extent and is considered more of a catch crop than one of the staple products.

The following is the four-year rotation practiced on some of the best farms around Alma: Corn on sod land, well manured, followed by beets, and then by oats or barley, seeding the land at the same time to clover or timothy. Beets are also an excellent crop to follow potatoes. Another rotation common with some prosperous farmers throughout the area is to manure timothy or clover sod for corn, crush the stubble and plow deep for sugar beets, followed by oats or barley, seeding to clover or timothy, then pasture one year, putting all the rough manure possible on the land. Wheat often follows oats or barley. Some believe that a continual cropping of timothy will soon cause the land to deteriorate in productiveness. A four-year, five-year, or even longer rotation should be practiced by every farmer in this area.

The sugar beet is also one of the important crops, and as it is practically new to the area, it deserves especial mention here. In the preparation of land for beets fall plowing is considered to give the best results. It is also essential that the plowing be deep, because the land then retains more moisture. The land should be plowed again in the spring and well pulverized to a depth of 8 or 10 inches, making a loose, light seed bed. Most of the seed is sown between the 10th and the 20th of May, although some is put in as late as the 1st of June. About 15 to 18 pounds of seed are commonly sown to the acre. The early sown seed should be covered from one-half to three-fourths of an inch deep, while that sown the last of May or first of June should be covered from 1 to 1½ inches deep. The rows are usually from 18 to 24 inches apart. Cultivation should begin as soon as the beets appear above the surface. Bunching and thinning are done when the beets have from three to five leaves. This is very important, in order to give the young plants a good start. Hand hoeing and horse cultivation are necessary until the tops meet in the rows. The harvesting of the beets is begun about the 1st of October. A horse puller, constructed especially for the purpose, loosens the beets and leaves them on the surface. After this they are topped with a knife at the base of the bottom leaf, and, the dirt being shaken from them, they are ready to be delivered to the factory.

AGRICULTURAL CONDITIONS.

The general appearance of the Alma area is that of a successful agricultural community. The soils for the most part are productive and suited to a variety of farm products, and these features, combined with sufficient rainfall, insure fairly stable returns from year to year. The buildings on the well-kept farms usually consist of a well-built house, neatly painted, and a large barn, usually painted red and of sufficient size to hold the hay crop and house the stock during the winter months. Windmills and tanks, supplying water for farm use, corn cribs, and shelters for farm machinery are seen on the best farms. Neat wire fences are taking the place of the rail, board, or stump fences which were first constructed. Log houses, still common in some parts of the area, are being supplanted by frame or brick buildings, and the general appearance of the farms is being changed with the general prosperity of this part of the county. On every good farm are found large horses to perform the farm work, several milch cows, supplying milk for home use and creameries, beef cattle, sheep, and hogs, with some poultry. The majority of the farmers own labor-saving machinery, comprising binders, mowers, rakes, cultivators, hay tedders and loaders, seed drills, gang plows, harrows, etc.

Probably about one-half of the farms in this area are mortgaged to some extent. These incumbrances were incurred, for the greater part, on account of purchases of more land or of farm implements, stock, windmills, or buildings, or in the installation of drainage systems. The indebtedness, as a rule, is not heavy, and individuals and financial institutions are willing to lend money on the farm lands. The best farm lands of the area, near the towns and railroads, are worth from $50 to $100 an acre, including all the improvements, while the same quality of land 10 miles distant from a railroad station will not sell for more than $30 to $50 an acre. Some of the more sandy lands in the northeastern and northwestern corners of the area can be bought for from $10 to $25 an acre. Lands within a radius of 10 miles of Alma have increased in value several dollars an acre since the sugar-beet industry was introduced. There are some farms in the area upon which a considerable sum has been expended for tile drains.

About 75 per cent of the farms in this area are operated directly by the owners and their immediate families, with one or more hired men. The remaining 25 per cent of the farms are operated through managers, who receive a fixed salary, or by cash or share tenants. The managers usually keep the farms in better condition than the tenants, and several of the best farms around Alma are run by managers. Only a small proportion of the farms are rented for cash, and comparatively few are let for a part of the crop.

The size of farms varies somewhat throughout the area. There are some of 40 acres, some of 60, 80, 120, 160, and some even larger, but 80 acres probably represents the average for the area surveyed. Sometimes one person owns many farms, thus making the average acreage to each landowner somewhat greater than 80 acres.

Labor is occasionally scarce and high priced, but a good grade of white help can generally be secured. Day laborers receive from $1 to $1.50 a day, while hired help working from six to nine months or longer in the year receive about $20 a month, with board and washing. Boys and girls can earn fair wages working in the beet fields. They are anxious to perform this work, and are becoming quite efficient in thinning and weeding beets. Their work is by the piece, and the usual price paid for thinning beets is 12 cents for a 40-rod row. During the harvesting season for beets men demand from $1.50 to $1.75 a day for their labor, and are rather disinclined to work during unfavorable weather.

General agriculture is practiced to a greater or less extent throughout the area. The principal products are corn, oats, hay (timothy and clover), sugar beets, wheat, beans, and potatoes; while the secondary crops are barley, rye, cucumbers, buckwheat, pumpkins, green peas, and garden vegetables, with fruits and berries. A large quantity of corn is annually grown. The acreage devoted to the production of wheat has been gradually decreasing in the last few years. Sugar beets are a money crop, and are now being considered in the regular crop rotation. Much of the navy bean crop grown in the area is contracted for by the wholesale seed dealers. The cucumbers are grown for the pickling factories, and are sold by the bushel. Quite a number of hogs and cattle are raised on every good farm, and many of these are fattened and shipped out of the area. From 1,000 to 3,000 sheep are also raised in each township, and many thousand pounds of wool are annually shorn. Milch cows are kept on nearly every farm, and some dairies were observed. A large quantity of milk is sold to creameries at Alma and Ithaca, while some cheese is made at the former place. Apples are the leading fruit, and a small orchard for home use is usually seen near the well-kept home. A considerable quantity of apples is shipped from the area, and much cider is also made. A few pear, plum, cherry, and a less number of peach trees, were noticed. Raspberries, blackberries, and strawberries are grown to a very limited extent. A few small vineyards are also seen. Some of the most successful and prosperous farmers sell nothing from their farms except sugar beets, cattle, sheep, and hogs.

Transportation facilities are furnished by the Ann Arbor Railroad, which runs across the area, connecting Frankfort and Toledo; and by the Pere Marquette Railroad, running through the area in an east and west direction. Dirt roads, which were laid out along section lines according to the Government land surveys, are found throughout the area, except across some of the more mucky or hilly portions. The roads, which are turnpiked, are constructed of excavated material dug from the drainage ditches on each side. There are a few gravel roads leading into Alma and St. Louis which were constructed by the beet companies. Rural free delivery of mail is in operation over the greater part of the area. It is not an uncommon thing to see a meat or grocery wagon making a house-to-house canvass in the rural districts.

There are no large cities in the area surveyed, and the local markets are somewhat limited. Alma and St. Louis each have a beet-sugar factory, and these places handle the sugar beets grown in the county, as well as some from the surrounding counties. These towns, together with Ithaca, offer some market for the other products. The hogs, cattle, and sheep are shipped to Buffalo, and all the grain is also shipped to the eastern markets. Grain elevators are located at all the railway stations, and a bean elevator is operated at Ithaca.

The salient characteristics of the soils as classified in the present survey may be stated briefly, as follows:

The Clyde loam, formerly in large part a swamp, is now the most extensive and productive of the soil types in the area surveyed. This soil has to be artificially drained in order to secure the best results. It is well adapted to corn, oats, wheat, and timothy, and is preeminently a sugar-beet soil. The beets have no difficulty in penetrating the clay subsoil, and a large, smooth beet with a fair and even high sugar content is obtained. The farmers recognize that this soil is adapted to beets. The timothy hay grown upon this soil is of a superior quality.

The soil next in importance and extent is the Miami fine sandy loam. It possesses the most varied topographic features of any soil in the area. All the crops common to the area are produced, but corn, oats, potatoes, beans, sugar beets, and apples seem to give the best results, although other crops can be successfully grown.

The Miami sand occupies a fairly large proportion of the area. The drainage of this soil, coupled with the loose, open texture of both the soil and subsoil, makes it an early and very easily tilled soil. It is suited to the production of small fruits, berries, peaches, potatoes, and cucumbers, and to light farming. Barley gives fairly good yields on this sand. Sugar beets can not be profitably grown on a commercial scale.

The Clyde sandy loam is also an easily tilled and fairly productive soil. Potatoes, beans, corn, clover, and berries are excellent crops for this soil. Sugar beets can also be grown with a fair degree of success and are recommended as a crop for this soil. Apples, cherries, and pears do well.

The Miami clay loam occurs most typically developed around Alma. Corn, oats, sugar beets, clover, timothy, and wheat give large yields. Tile drains have proved beneficial in regulating the soil moisture and aerating this soil.

The Clyde sand, owing to its intimate connection with the Muck areas, has for the most part poor natural surface drainage. It is, however, well suited to corn, cabbages, celery, potatoes, and hay, while some of the more elevated areas, where the drainage is good, will produce large yields of beets and other crops.

The Muck soil of this area is as yet undeveloped, except in small spots, but when it is cleared, ditched, exposed to the sun, and cultivated for a few seasons it will produce large yields of onions, cabbages, and celery.

The Miami gravelly sand, by reason of its coarse, open texture, is liable to suffer seriously from drought. However, some of the more loamy areas of this soil along Pine River will produce fair yields of corn, oats, barley, beans, potatoes, cucumbers, and fruits.

The Meadow land of this area is not considered in an agricultural way, except as pasture ranges for cattle. There are no large areas of this type.

SOIL SURVEY OF THE OWOSSO AREA, MICHIGAN.

By A. W. MANGUM and CHARLES J. MANN.

LOCATION AND BOUNDARIES OF THE AREA.

The area surveyed embraces the northern eight townships of Shiawassee County, which is situated in the central part of the lower peninsula of Michigan. From the fact that the two western townships, Fairfield and Middlebury, are smaller than the others, the

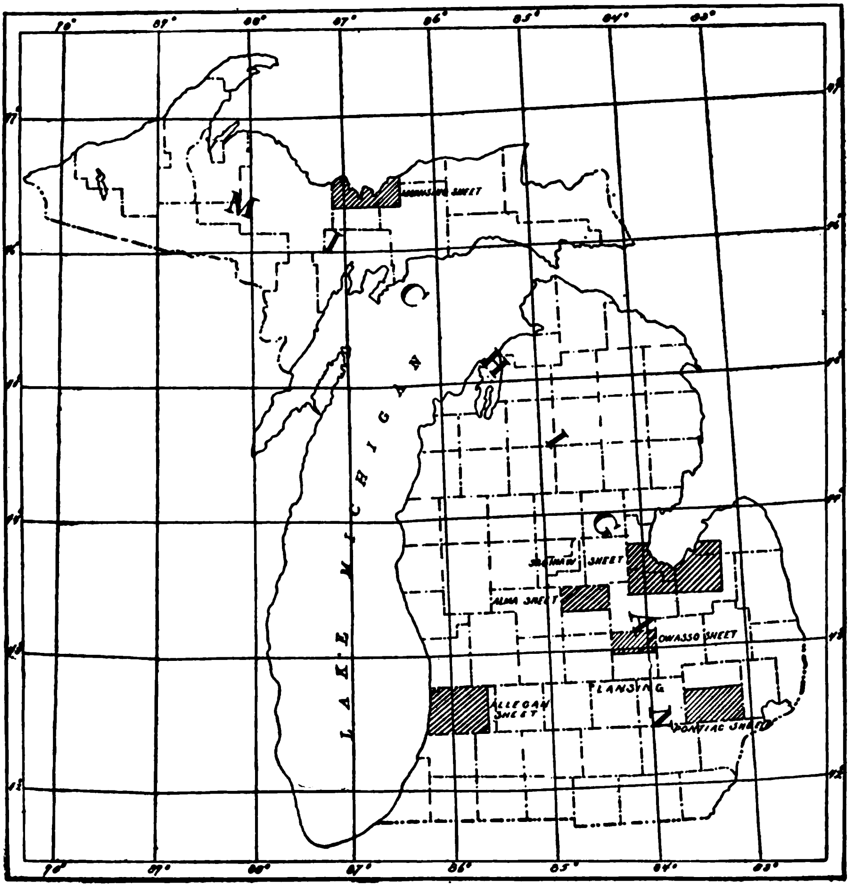

FIG. 27.—Sketch map showing location of the Owosso area, Michigan.

total area of the eight townships is but 270 square miles. The area is bounded on the north by Saginaw County, on the east by Genesee County, on the west by Clinton County, and on the south by Scioto, Bennington, Shiawassee, and Vernon townships of Shiawassee County.

The first principal meridian extends along the western boundary, between Clinton and Shiawassee counties.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Shiawassee County was organized in 1822, although at that time the white population consisted of only a few trappers and fur traders. From that year until 1835 the settlement of the region was very slow and, indeed, a part of the county territory was held by the Saginaw Indians until 1842.

Settlement was not retarded so much by Indian occupation, however, as by the character of the lands, which were heavily timbered, and by the lack of roads, travel over the trails used by the Indians being slow and difficult. In 1835 a large number of settlers began to arrive from New York, Massachusetts, Vermont, and other Eastern States, as well as from many of the older settlements in eastern Michigan. The greater number of these immigrants came from New York.

The first care of the pioneer settlers was to grow such crops as would provide their families with the necessaries of life, and wheat, being well adapted to the climatic conditions and soils, was at first the only crop cultivated. Later potatoes and corn were introduced and cultivated to a limited extent, but almost all the cleared lands were devoted to wheat. The yield obtained soon exceeded the local demand, and the farmers began to realize annually a small income from the sale of a part of the crop. The great distance to the markets, together with the large yields annually obtained, kept the prices low, and the profits were at first small. As the population of the county was yearly increased by the arrival of new settlers from the Eastern States, larger tracts of land were cleared and cultivated, and a greater diversity of crops was grown.

In 1850 an agricultural society was established for the purpose of holding annual fairs, at which the general farm products of the area were exhibited, but very little interest was manifested in this society until it was reorganized in 1860.

In 1850 the total number of occupied farms in the county was 746, and of the total area 31,203 acres were classed as improved. In 1874 the number of acres of improved land had reached 118,781, and in 1900 it was 260,650. The population of the county had also increased from 5,233 in 1850 to 33,866 in 1900.

In 1856 the first railroad reached the area. This was the Detroit and Milwaukee line, later the Detroit, Grand Haven and Milwaukee Railway, now a part of the Grand Trunk system. This road entered the county in Vernon Township, and extended west as far as Owosso. In 1862 the Amboy, Lansing and Traverse Bay Company opened a road to Owosso, which eventually came under the control of the Michigan Central Railroad Company. These roads, together with the Toledo, Ann Arbor and Northern Michigan and the Cincinnati, Saginaw and Mackinaw railroads, which also traverse the area, connect all parts of the county with important points, both north and south, and have been important factors in the development of the area.

The growth and agricultural development of Shiawassee County has been slow but steady. A large proportion of the tillable lands of the area is at present under cultivation, and a great variety of crops is grown. The cultivation of wheat has been the foundation of the agricultural wealth and prosperity of the area, and wheat has continued to be the most important product of the county up to within the last few years, since which time failures to obtain profitable yields have greatly decreased the acreage devoted to it.

CLIMATE.

The following table, compiled from records of the Weather Bureau, gives the normal monthly and annual temperature and precipitation of Shiawassee County. The records were taken at Ovid, in the western part of the county, and at Flint, situated a short distance east of the area. They are believed to represent fairly the climatic conditions of the whole county.

Normal monthly and annual temperature and precipitation.

Month.	Ovid.		Flint.		Month.	Ovid.		Flint.	
	Temperature.	Precipitation.	Temperature.	Precipitation.		Temperature.	Precipitation.	Temperature.	Precipitation.
	° F.	*Inches.*	*° F.*	*Inches.*		*° F.*	*Inches.*	*° F.*	*Inches.*
January	22.5	1.82	22.2	1.54	August	67.9	2.23	67.6	2.36
February	21.2	2.25	20.8	1.42	September	60.8	2.26	61.2	2.60
March	30.0	3.20	29.9	1.71	October	48.8	2.29	48.9	1.91
April	45.6	2.16	45.3	1.91	November	36.4	2.66	35.9	2.61
May	56.2	3.66	56.1	3.65	December	27.4	2.09	27.0	1.79
June	67.5	3.21	66.2	2.86	Year	46.3	30.98	45.9	27.32
July	71.2	3.15	70.1	2.96					

The following table gives the dates of first and last killing frosts, as observed by the Weather Bureau at Ovid and Flint during the period 1896 to 1903. These data represent fairly the conditions in the area surveyed, and show that there is an average period of about five months during which vegetation is free from damage by frosts.

Dates of first and last killing frosts.

Year.	Ovid.		Flint.	
	Last in spring.	First in fall.	Last in spring.	First in fall.
1896	Apr. 22	Sept. 23	Apr. 22	....
1897	Apr. 19	Sept. 21	....	Sept. 21
1898	May 6	Oct. 29	May 7	Sept. 11
1899	....	Sept. 14	....	....
1900	May 5	Oct. 17	....	Oct. 17
1901	Apr. 20	Sept. 19	Apr. 21	Oct. 4
1902	May 28	Oct. 10	May 15	Oct. 10
1903	May 8	Oct. 18	May 4	Sept. 29
Average	May 3	Oct. 4	May 2	Sept. 30

PHYSIOGRAPHY AND GEOLOGY.

There are two general physiographic divisions in the Owosso area. The northeastern half of the area lies within the old basin of glacial Lake Saginaw, while the remainder is composed of rolling upland. Within these two divisions the topographic features are varied. The basin of the old glacial lake has the general appearance of a level plain, but low rounded knolls and ridges, with shallow depressions intervening, give it a gently rolling topography. Along the Shiawassee River, which traverses this section in a northerly direction, the topography is more broken. Here the greatest amount of erosion has taken place. The stream valley is often narrow and deep, and the slopes of the rounded knolls and ridges are usually steep and excessively drained.

In the extreme northern portion of the part of the basin included in the survey a series of narrow ridges of sand and gravel extends east and west from near the eastern to the northwestern boundary of the county. These ridges are seldom more than one-fourth of a mile wide, and are probably the remains of an old beach line.

The upland division is very rolling and uneven, the result of glaciation. The rounded hills and ridges extend across the area in a general northwest to southeast direction. The slopes gradually become steeper and more broken as the southern boundary of the area is approached, but they are never so steep as to interfere with cultivation.

Along the southern boundary, especially in the south-central part of the area, the topography becomes more typical of the glacial moraine. Sharp drift knolls of sand and gravel, with kettlelike depressions and small shallow basins intervening, are scattered at short intervals over this part of the uplands. There are some large gravelly areas near Ovid, in the southwestern part of the area, which are in many respects similar to the region last described. The topography is quite rolling, and sharp knolls and narrow ridges occur frequently. However, the shallow depressions between them, unlike those in the "kame and kettle" topography, have a gentle slope toward the small streams and are well drained.

Extending across the southern part of the area, from east to west, is a well-defined valley of an ancient glacial stream, having an average width of one-half to three-fourths of a mile. This valley leaves the county near Ovid, in the southwestern part of the area surveyed. Its surface is comparatively level, the gentle swells and better drained areas consisting mostly of sand and the depressions usually of peat or muck. The southern escarpment of the valley is usually steeper and more clearly defined than the northern, often rising many feet above the level of the small streams or swampy depressions that now occupy the old channel. Deposits of rounded, waterworn gravel occur on the steeper slopes and low ridges on each side of the valley.

A second old stream channel enters the area in the extreme southern part of Owosso Township and joins the former near the southern boundary of the area. Another prominent topographic feature of the area consists of two depressions, together comprising about 8 square miles, occurring in the northwestern part of the county. These areas, surrounded by the rolling uplands, are poorly drained, and are now occupied by extensive peat bogs. Other smaller areas of a similar character occur in various parts of the county.

When the ice covered the northern part of the area, the drainage was probably westward through an ancient stream which followed the broad, shallow valley already described, but as the ice sheet receded the drainage of the greater part of the area was toward Lake Huron, and the streams cut their channels northward, finally reaching the lake at Saginaw Bay. The Shiawassee River flows through the old stream valley from east of Corunna to the city of Owosso, at which point it turns northward and runs in a deep, narrow channel, which it has carved out between the rounded hills in comparatively recent time. The rolling hills of the west-central part of the area form a divide for the drainage of the county. The eastern three-fourths of the area, with the exception of the northeastern portion, is drained by the Shiawassee River and its small tributaries. This river is the principal stream of the county, and flows across the area in a general northwest course, finally emptying into the Saginaw River. The southwestern part of the area is drained by the Maple River, which occupies the western part of the valley eroded by the old glacial stream, finally emptying into the Grand River, whose waters eventually reach Lake Michigan. Misteauguay Creek, which drains the greater part of Hazelton and Vernon townships, leaves the area in the extreme northeastern corner and empties into the Flint River.

The valleys formed by the streams since the ice invasion are deep and narrow. The steep slopes extend to the immediate banks of the stream, and there is practically no bottom land or alluvial deposit along their course. Small glacial bowlders are scattered over all sections of the area, but they never occur in sufficient number to affect the agricultural value of the land.

The geological formations of the area belong to the Carboniferous period, but they are covered to varying depths by glacial drift. There is a small exposure of the underlying sandstone near the river bluff a few miles east of Corunna, but the drift at the coal mines, a few miles north, ranges from 10 to 30 feet in depth, while at some other points in the county it is estimated to be over 100 feet deep.

There are three coal mines located a few miles northeast of Corunna, only one of which is being worked at present. Deposits of clay, suitable for the manufacture of Portland cement, occur in the same locality, and these are now being worked to a limited extent.

SOILS.

Nine types of soil, including Meadow and Muck, are found in the area surveyed. The following table gives the actual and relative extent of each type.

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Clyde loam	71,744	41.5	Meadow	2,688	1.6
Miami clay loam	62,464	36.1	Miami fine sandy loam	2,624	1.5
Miami gravelly sand	14,080	8.1	Saginaw sandy loam	1,280	.7
Miami fine sand	7,808	4.5			
Muck	6,400	3.7	Total	172,800	
Miami sand	3,712	2.1			

CLYDE LOAM.

The Clyde loam is the most important soil type mapped in the survey, both as to extent of area and agricultural value. It is more uniform as to depth, texture, and topographic features than any other type in the area. The soil consists of about 10 inches of heavy black to dark-brown loam, which contains a sufficient amount of silt and clay to give it many of the characteristics of a heavy silt or clay loam. The dark color of the soil is due to the organic matter always present in large proportions, varying slightly with differences in topography. The lighter colored areas, occupying the gentle swells, contain the smaller amount, while in the depressions, where the soil is of a very dark brown to black color, there have been heavier accumulations of humus.

The first few inches of the subsoil consists of a very heavy light-brown slightly mottled clay loam, the clay content gradually increasing and the soil becoming stiffer and more tenacious with depth. From about 25 to 36 inches it is a slightly mottled heavy clay loam or clay, but still contains a small percentage of sand.

When properly cultivated the soil breaks up into a loose friable loam, the sand content, together with the large amount of organic matter present, giving it a very desirable tilth. The surface becomes baked and sun-cracked when not under cultivation, and if plowed in a wet condition hard clods are formed, making it very difficult to reduce the soil to a state of thorough cultivation.

A few small areas of the Clyde loam, occupying the level depressions between the narrow gravel ridges in the northern part of the county, contain a slightly higher percentage of sand in both soil and subsoil than is present in the greater part of this type. This is due to the washing in of sand from the neighboring ridges and to the deposition of a larger amount of sand near the base of the old beach lines.

The Clyde loam extends in one broad area from the extreme northwestern part of the county to the southeastern boundary of the area, and occupies the greater part of Hazelton, New Haven, and Rush townships, and the northern part of Fairfield and Caledonia townships. It also occurs in smaller areas in every township surveyed. Small patches of sand or other soils occur at intervals scattered through the larger area, but it is broken only by a narrow strip of Miami clay loam which extends along the course of the Shiawassee River.

This soil occupies the most level portion of Shiawassee County, which is believed to be the basin of an ancient lake. The principal topographic features consist of low rounded knolls and gentle swells, with broad flat areas or shallow depressions lying between them. Where the topography becomes more rolling or broken the soil becomes lighter and grades into the Miami clay loam or into the small sandy areas which occupy the higher ridges and elevations. The natural drainage furnished by the topography is sufficient to carry off the excess water during times of heavy rainfall, and only the lower depressions remain in a condition too wet for cultivation for any considerable length of time.

The heaviest phase of the type is found in these low, poorly drained depressions. Here, under wet conditions, finer material, washed in from the more rolling areas, has combined with an accumulation of organic matter and formed a black loam that is slightly heavier than the typical soil. Such conditions, however, exist only in one or two small areas near the boundaries of the larger tamarack swamps, where the natural drainage is very poor.

The lighter phase occurs on the summits of the knolls and ridges where the soil is thoroughly drained and only a small percentage of organic matter is present.

A number of drains have been constructed through the more level areas of this type, but tile drainage is at present practiced only to a very limited extent.

As already pointed out, the old glacial Lake Saginaw once covered the section of the area occupied by the Clyde loam, and the material from which the soil is formed was deposited in this lake. The large amount of organic matter found in the soil probably owes its origin to the swampy and poorly drained condition that existed in this part of the area during the period following the subsidence of the lake.

This soil is better adapted to the growing of sugar beets than any other type in the area, and is also well adapted to wheat, oats, corn, and all general farm crops grown in this part of the State. The average yields are as follows: Corn, about 80 bushels of ears, although a yield of 100 bushels per acre is quite often obtained; wheat, up to within the last few years, about 18 bushels per acre, but the average for the last two or three seasons is less than 12 bushels per acre, while the crop for the present season (1904) is estimated at a still lower figure; oats, from 40 to 50 bushels; pea beans or navy beans, which are extensively cultivated, from 18 to 20 bushels per acre, and sugar beets, when well cultivated, from 10 to 20 tons per acre.

The following table gives the results of mechanical analyses of typical samples of this soil:

Mechanical analyses of Clyde loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11526	SW. ¼ sec. 11, Venice Tp.	Loam, 0 to 10 inches	0.4	3.4	6.3	24.9	22.5	26.5	15.8
11522	Sec. 16, New Haven Tp.	Dark heavy loam, 0 to 10 inches.	.6	3.0	4.9	17.2	17.4	36.0	20.8
11524	NE. cor. sec. 13, Rush Tp.	Dark heavy loam, 0 to 10 inches.	.4	2.9	5.2	20.2	18.2	29.4	23.6
11523	Subsoil of 11522	Clay loam, 10 to 36 inches.	.8	3.6	5.2	17.3	14.7	31.6	26.6
11525	Subsoil of 11524	Heavy clay loam, 10 to 36 inches.	.6	3.1	3.8	17.4	17.4	27.5	30.1
11527	Subsoil of 11526	Heavy clay loam, 10 to 36 inches.	.7	2.3	3.5	13.4	15.5	33.2	31.3

The following sample contains more than one-half per cent of calcium carbonate ($CaCO_3$): No. 11522, 1.1 per cent.

MIAMI CLAY LOAM.

The Miami clay loam is the second soil of the area, both in extent and agricultural importance. The soil is a light-brown or yellow loam, made up principally of the finer grades of sand and silt, but containing enough heavy material to give it coherence and cause it to lump and clod to a considerable degree. At a depth of 6 or 7 inches a thin layer of light-colored, friable, silty material separates the soil from the true subsoil. The subsoil, from 10 to 36 inches, is a reddish-brown or yellow clay or clay loam, in which particles of coarse sand and occasional gravel are present. The upper 4 or 5 inches are usually friable and silty, but the material gradually becomes stiffer and heavier as the depth increases. Upon drying the surface of the soil assumes a light-yellow, or almost white appearance, and where the hillsides have been slightly eroded it has a light-brown color, due to the fact that the underlying subsoil has been brought near the surface and turned up with the plow.

The soil contains a moderate quantity of organic matter, though much less than the Clyde loam. Where it borders the latter type, in areas less rolling than the average, and where it occupies the slight elevations in the more level parts of the county, the percentage of humus is higher and the soil of a darker shade.

Gravel and small bowlders frequently occur, scattered over small areas, but are seldom so numerous as to interfere with the cultivation of the soil. In most cases the stones and small bowlders have been gathered into piles or removed from the fields.

Small ridges and knolls of sand or gravel occur at intervals throughout the entire area embraced by this soil type, and where these are of sufficient size they have been indicated on the soil map. A large number, however, do not exceed an acre in extent. In like manner, small areas of Clyde loam frequently occur in the shallow depressions, where an accumulation of organic matter and poor drainage have given rise to a heavier black soil.

The Miami clay loam occurs in one unbroken area extending from the southeastern to the northwestern boundary of the area surveyed. Small areas, occupying slight knolls and ridges, occur in every township, but on the whole the type is confined to the more rolling uplands and the broken country along the course of the principal streams.

The topography varies from gently undulating to rolling, but the slopes are never steep enough to interfere with cultivation or to cause the soils to suffer seriously from erosion. Low, rounded hills, with gentle slopes and prominent knolls and ridges, which indicate the glacial origin of the soil, are the principal physiographic features of the type.

The Miami clay loam is derived from the weathering of the glacial drift, which in this section of the area covers the underlying geological formations to a great depth. The material making up the deep subsoil consists mainly of a mottled silt and clay, containing considerable sand and an occasional pebble or small bowlder. The subsoil holds moisture very well, and in some cases is so stiff that it is difficult for water to percolate through it. In such cases tile drainage would be very beneficial. Where a good system of underdrainage has been established crop values have been greatly increased. In general, the rolling topography furnishes an adequate means for carrying off the surface waters, and there would seldom be any difficulty in finding a convenient outlet for a system of tile drainage.

The soil is well adapted to beans, and, when well cultivated, gives profitable yields of corn, oats, wheat, and hay. It is not so well adapted to the production of sugar beets as the Clyde loam, but under favorable conditions fair crops are obtained. When beets are to be grown an area should be selected where the soil is uniform and the topography is comparatively level, in order that the cultural needs of the various parts of the field should be as nearly as possible the same at the same time of the season.

Under ordinary conditions a yield of 35 bushels of corn per acre is obtained year after year, and it is not uncommon for this soil to produce 40 or 45 bushels per acre during a favorable season. The yield of wheat has been low during the last four years, but from 15 to 18 bushels per acre is considered an average yield in a favorable season. Oats yield on an average 40 bushels, and beans from 18 to 20 bushels per acre. Clover and timothy are usually sown together, and yield from 1½ to 2 tons of hay per acre. Sugar beets are not extensively grown. From 8 to 10 tons per acre is estimated to be the average yield.

The following table gives the results of mechanical analyses of the fine earth of the soil and subsoil of the Miami clay loam:

Mechanical analyses of Miami clay loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11498	Sec. 6, New Haven Tp.	Gray silty loam, 0 to 12 inches.	1.2	2.5	4.3	18.0	20.4	44.1	9.2
11500	SE. cor. sec. 30, Venice Tp.	Gray loam, 0 to 10 inches.	5.0	7.1	7.7	19.7	11.6	30.2	18.5
11499	Subsoil of 11498	Heavy loam, 12 to 36 inches.	.6	2.0	3.5	14.8	15.4	42.6	21.0
11501	Subsoil of 11500	Heavy clay loam, 10 to 36 inches.	1.6	3.4	5.0	13.7	10.5	29.4	36.3

MIAMI FINE SANDY LOAM.

The Miami fine sandy loam is one of the less important types of the area, covering in all only about 4 square miles. An average section would show a medium to fine sandy loam of a light-brown to yellow color, 10 to 12 inches deep, underlain by a heavier sandy loam that grades into a heavy clay loam. The subsoil is similar to that of the Miami clay loam, and in fact the same material underlies practically all the upland soils of this region. The section described above should be taken as an average, and not as the uniform soil condition over any very considerable areas. The soil on the crests of the knolls is generally more sandy, and the sand often extends to a depth of 2 or 3 feet. A small quantity of gravel is also occasionally found scattered through these more sandy areas of the type. On the slopes the heavy subsoil is nearer the surface, and the soil itself is less sandy. Such areas are very similar to the Miami clay loam, but as they occur only in patches of from a fraction of an acre to 3 or 4 acres in extent it was not practicable to indicate them on a map of the scale used.

The characteristic feature of this type is its topography, and the nature of the soil results largely from the surface peculiarities. Areas where the type occurs are marked by the "kame and kettle" topography, common in glaciated regions. Small, rounded knolls with intervening kettlelike depressions give the whole surface of the area a very broken appearance.

This soil for the most part is well drained, but many of the depressions have no natural outlet, and where they are of sufficient size give rise to small, marshy areas, unfit for cultivation. In other depressions a large amount of organic matter has accumulated, causing the soil to be of a darker color and slightly heavier texture. The higher knolls and steeper slopes are often too thoroughly drained, during a season of average rainfall, to give the best results with the crops cultivated.

The Miami fine sandy loam is of morainic origin, which accounts for its varied character. It is really a mixture of the materials composing the light sandy soils and the Miami clay loam, which have combined as a result of the peculiar nature of their occurrence.

A yield of about 60 bushels per acre of corn on the cob is obtained during a season of average rainfall, and for oats 40 bushels per acre is considered an average yield. Beans yield from 12 to 15 bushels per acre. Wheat is not well adapted to the conditions that exist in this section of the area, and is seldom cultivated. Clover and timothy produce from 1 to 1½ tons of hay per acre. The soil is well adapted to potatoes, and from 150 to 200 bushels per acre are obtained. It is also well suited to fruits, and small apple orchards, in a flourishing condition and annually producing large yields, are seen scattered over this area.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Miami fine sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11484	SW. cor. sec. 36, Caledonia Tp.	Sandy loam, 0 to 12 inches.	3.2	6.7	8.4	24.5	17.1	28.5	11.3
11486	SW. ¼ sec. 32, Caledonia Tp.	Brown sandy loam, 0 to 10 inches.	2.8	6.7	9.0	28.8	16.3	25.6	11.3
11487	Subsoil of 11486	Brown heavy loam, 10 to 36 inches.	1.0	5.0	7.7	22.6	14.6	23.8	25.8
11485	Subsoil of 11484	Clay loam, 12 to 36 inches.	1.2	5.0	6.8	19.2	14.7	26.8	26.3

MIAMI FINE SAND.

The soil of the Miami fine sand, to a depth of 12 inches, consists of a medium to fine sand of a light-brown to yellow color. The mineral particles form a loose and incoherent mass, but a small amount of humus in the first few inches of the surface soil gives it a slightly loamy texture. The subsoil, extending from 12 to 36 inches, is usually a loose yellow to red sand of about the same grade as the soil. On the lower slopes of the rounded knolls and where the type occupies small depressed or level areas the subsoil frequently becomes heavier at about 30 inches, in such places consisting of a sticky yellow or red sand.

Small areas of the Miami fine sand are found in almost every township surveyed, but its most frequent occurrence is in the northwestern part of the area, in Fairfield and Rush townships. The principal topographic features of these areas consist of low, narrow ridges or rounded elevations with gently sloping sides. This configuration gives the larger areas a slightly rolling appearance.

The loose, sandy character of the soil and subsoil, together with its topography, causes this type to be thoroughly drained, but in an average season a sufficient amount of moisture is retained in the soil for the production of the crops grown. Larger yields, however, are always obtained during wet seasons.

The sandy knolls and ridges formed of the Miami fine sand are made up of reworked glacial drift, deposited with the aid of water, and owe their origin either to the streams issuing from the ice sheet or to the deposition of material along the shores of the glacial lake.

The average yield of corn on this soil ranges from 20 to 25 bushels per acre; wheat yields 10 bushels; oats, about 25 bushels; and beans, from 10 to 12 bushels per acre. Potatoes and vegetables do well, and are well adapted to the soil. Clover and timothy produce fair yields. Sugar beets have been grown to a limited extent, and under favorable conditions yield from 7 to 10 tons per acre.

The following table gives the results of mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Miami fine sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11510	NW. ¼ sec. 4, Rush Tp.	Loose fine sand, 0 to 12 inches.	0.0	1.8	16.6	67.5	6.9	3.9	3.4
11512	SE. cor. sec. 15, Fairfield Tp.	Sand, 0 to 12 inches.......	.1	6.9	17.3	43.0	14.6	12.3	5.5
11511	Subsoil of 11510......	Fine sand, 12 to 36 inches.	.2	2.3	15.9	66.1	8.2	3.8	3.1
11513	Subsoil of 11512......	Medium to fine sand, 12 to 36 inches.	.2	7.0	18.3	46.9	14.8	8.8	3.8

SAGINAW SANDY LOAM.

The soil of the Saginaw sandy loam is a black or dark-brown medium to fine sandy loam, with an average depth of 12 inches, and containing a very large proportion of organic matter. It is underlain by a thin layer of loose medium to fine sand of a whitish, bleached appearance. This grades into a gray sand of somewhat coarser texture, which becomes sticky as the depth increases and frequently contains a considerable proportion of clay. The subsoil is often slightly mottled with yellow or red iron stains, and thin layers of the stiff blue clay, which underlies the sand at no great depth, are sometimes encountered at a depth of from 20 to 36 inches.

The Saginaw sandy loam occurs in a few small areas in the northern part and in two small depressions in the southwestern part of the area. It covers in all an area of less than 3 square miles.

This soil occurs in small, shallow basins that have only recently emerged from a swampy condition, and where, even now, the drainage is insufficient. These depressions are almost entirely surrounded by low knolls and ridges, making it difficult to drain them thoroughly. The lower depths of the subsoil are usually in a wet, soggy condition, and a considerable portion of the whole type is too poorly drained to be of much agricultural value.

The Saginaw sandy loam has been formed by the accumulation of large quantities of organic matter in poorly drained, sandy depressions. The slowly decomposing organic matter has become mixed with the sand washed in from the neighboring slopes, and a black sandy loam soil is the result. In the more swampy depressions the soil has many of the characteristics of Muck.

Only a small proportion of the area of this soil is at present under cultivation, the greater part being used exclusively as pasture land; but where thoroughly drained fair yields of corn, oats, timothy and clover, and beans are produced. Wheat is rarely grown on these lands, as the yield is seldom large enough to make it a profitable crop.

Corn produces from 35 to 40 bushels; oats, from 25 to 30 bushels; timothy and clover, from 1 to 1½ tons of hay; and navy beans, from 8 to 10 bushels per acre.

The following table gives mechanical analyses of this soil:

Mechanical analyses of Saginaw sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11508	SW. ¼ sec 3, Rush Tp.	Sandy loam, 0 to 10 inches.	1.8	9.6	16.4	47.4	6.7	13.7	4.4
11506	NW. cor. sec. 10, Fairfield Tp.	Black sandy loam, 0 to 18 inches.	2.5	11.5	24.1	37.6	6.1	11.7	6.3
11507	Subsoil of 11506	Sand, 18 to 36 inches	4.5	15.8	34.8	19.5	8.3	10.0	6.9
11509	Subsoil of 11508	Light gray sand, 10 to 36 inches.	.4	2.8	12.4	47.8	12.8	16.2	7.0

MIAMI GRAVELLY SAND.

The Miami gravelly sand consists of a gray to light-brown sand or sandy loam about 12 inches deep, and containing a high percentage of gravel, underlain by a medium to coarse yellow or red sand, also carrying a large proportion of fine and coarse gravel. The material composing the subsoil is cemented, it is believed, with iron, and often consists of a compact mass of sand and gravel, with many of the characteristics of a hardpan, although it is never so hard as to prevent the penetration of plant roots.

Small sandy areas occur in this type where the gravel content of the surface soil is low and where the sand has been deposited to a greater depth above the coarser material forming the subsoil. These areas occupy the shallow depressions or more level areas between the sharp knolls and ridges. The contrary is true of the steeper slopes and ridges along the stream courses, and small areas occur at frequent intervals where from 30 to 40 per cent of the surface is composed of gravel. The stone particles vary in size from coarse sand to cobbles several inches in diameter. On most of the narrow ridges the finer sand particles are gradually being washed down to the lower levels, leaving the coarser material exposed on the surface, and causing a deeper accumulation of sand along the lower slopes.

The Miami gravelly sand occupies long, narrow ridges in the northern part of the area, and also the steeper slopes bordering the larger streams. It occurs most extensively in Middlebury Township, in the southwestern part of the area, but areas of smaller extent are found in the more rolling sections throughout the survey.

Although the topography is rolling, with frequent well-defined knolls and ridges, the slopes are gentle, except along the immediate banks of the larger streams, and the soil over the greater part of the area suffers very little from the effects of erosion. The topography and porosity of the soil insure good drainage. The areas occupying the steeper slopes are often too well drained, and the crops suffer to some extent from the effects of drought, but during a season of average rainfall sufficient moisture is retained in the soil occupying the rolling hills to supply the needs of the crops cultivated.

The areas of the Miami gravelly sand in the northern part of the county were probably deposited along the beach lines of the old glacial lake. The larger area in Middlebury Township is derived from the coarser material deposited here as glacial outwash, while the narrow strips along the old stream valley consist of the sand and gravel laid down along the banks of the old channel while it served as an outlet for the waters from the melting ice.

This soil is well adapted to fruits, and excellent yields are realized from the small orchards located on it. It also produces very profitable yields of beans and corn. Clover also does well, but the type is not well adapted to timothy. When well cultivated, the yields of all the general farm crops of the area compare very favorably with those obtained from the heavier types of soil. Corn yields an average of 60 bushels of ears per acre, and wheat, in an average season, from 12 to 15 bushels per acre. Oats are considered a sure crop, and give an average yield of from 35 to 40 bushels per acre. Clover and timothy are usually sown together, and the average yield of hay is about 1½ tons per acre. Beans do well, and yields of from 15 to 18 bushels per acre are annually realized. Very few sugar beets are grown, but a fair yield has been obtained on the limited areas cultivated to them. Potatoes yield from 150 to 200 bushels per acre, and other vegetables do exceedingly well.

The following table gives the results of mechanical analyses of typical samples of fine earth of the soil and subsoil of the Miami gravelly sand:

Mechanical analyses of Miami gravelly sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11492	NE. cor. sec. 12, New Haven Tp.	Sand, 0 to 12 inches.......	6.4	21.7	26.8	29.6	5.8	6.8	3.7
11490	SE. cor. sec. 35, Middlebury Tp.	Brown sandy loam, 0 to 10 inches.	3.7	18.0	15.6	25.8	10.0	20.8	5.8
11493	Subsoil of 11492	Red to brown sand, 12 to 36 inches.	4.9	19.4	27.1	38.6	3.2	3.3	3.2
11491	Subsoil of 11490	Sand containing gravel, 10 to 36 inches.	7.9	36.1	20.7	18.1	4.7	5.9	6.6

MIAMI SAND.

The surface soil of the Miami sand is a dark-brown to gray loamy sand, the color varying in proportion to the amount of organic matter it contains. The sand is mostly of medium and fine grades, but, as is common with soils of similar origin, small areas of a coarser or finer texture also occur. At an average depth of 12 inches the soil grades into a sand of slightly coarser texture, which varies in color from light yellow to red. Gravel, clay, or sticky sand underlies this sand at a depth of 3 feet or more, and thin bands of clay or gravel are often encountered at a depth of 25 or 30 inches.

This soil occurs in a few small areas along the old glacial stream valley that extends across the southern part of the area, and is of minor importance, both in extent and agricultural value. The largest area occurs just north of Corunna, in that part of the old valley now occupied by the Shiawassee River.

The topography is comparatively level, with gentle swells and shallow, basinlike depressions. One or two well-defined terraces of the old river channel occur in the larger area of the type.

The level and gently undulating areas are comparatively well drained, but in many of the shallow depressions the drainage is very poor, and accumulated organic matter has become mixed with the sand, producing small mucky areas unfit for cultivation. These areas are of very small extent, and are not indicated on the map. The materials of the Miami sand really occupy the greater part of the old stream valley, but where the drainage has been insufficient they have been buried under an accumulation of peat or are in a condition too wet and swampy for agricultural purposes. Only those areas that have been thoroughly drained by the Shia River have been shown on the map as the Miami sanc

The sand, gravel, and finer material composing th posited in the bed of the old glacial stream which g occupied this valley soon after the ice invasion, and of gravel and coarse material which frequently occui in the swifter currents of the ancient stream. The of coarse and fine material sometimes encountered in the beds of gravel or clay that occur at varying deptl profile, also point to alluvial deposition as the origin

The Miami sand is well adapted to truck, and larg profitably utilized in growing vegetables for the loca tatoes are also well suited to this soil, and always pr profitable yields. The soil is not well adapted to t crops, and the yields obtained are small as compared duced on the heavier soils. The crops grown and av as follows: Oats, 30 bushels per acre; beans, from corn, 20 bushels, and potatoes, from 150 to 200 bush moderate yield of hay is secured, but wheat is seldoı yields are very small.

The following table gives the results of mechan samples of fine earth of the soil and subsoil of this tyı

Mechanical analyses of Miami sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.
			P. ct.	*P. ct.*	*P. ct.*
11516	Sec. 23, Middlebury Township.	Light loamy sand, 0 to 12 inches.	3.1	9.2	14.7
11518	Sec. 19, Caledonia Township.	Brown to gray sand, 0 to 8 inches.	2.8	12.8	18.9
11517	Subsoil of 11516	Loose sand, 12 to 36 inches.	1.9	10.2	16.2
11519	Subsoil of 11518	Sand, 8 to 36 inches.......	6.5	15.5	19.8

MEADOW.

The soils mapped as Meadow consist of poorly drai ring along the streams, usually in a condition too wet These areas are composed of a variety of materials washed in from the rolling uplands or deposited by incorporated with varying proportions of organic ma stages of decomposition.

The small areas occupying the slight elevations ciently drained to permit cultivation, but the great the Meadow consists of small areas of peat, muck, sand, and clay so intermingled that it was impracticable to attempt to map them in separate classes, and in such a poorly drained condition that they are suitable at best only for pasture land.

MUCK.

Two large depressions in the western part of the area have been classified as Muck. The surface is usually dry and of a brown color, but as the depth increases the material becomes more or less saturated with water, is black in color and mucky in texture. The depth of the accumulated organic matter ranges from 2 to more than 10 feet.

These areas occupy basins surrounded by rolling hills, and do not have outlets affording adequate drainage. They are now covered by a heavy growth of tamarack and a species of poplar. The surface deposits are usually underlain by a light-colored sand, which resembles the subsoil of the Saginaw sandy loam. Another area of considerable size occurs in that part of the old stream valley which has been only partially drained by the small stream now occupying it, and areas of smaller extent are found in various places throughout the territory embraced by the survey.

At the present time the areas of Muck are of little agricultural value. Considerable areas have been burned off, leaving the underlying sand exposed on the surface. If properly managed and more thoroughly drained, the areas of this soil type would be valuable for the production of potatoes, onions, celery, and garden truck.

AGRICULTURAL METHODS.

The agriculture of the Owosso area belongs to the class usually designated as "general farming." A variety of crops is grown, and the work is well distributed throughout the season, so that it can be accomplished without the aid of much hired labor. On a farm of only 80 acres as many as five or six distinct farm crops may be grown, leaving besides a considerable acreage allotted to timber land, pasture, orchard, and garden. The rotation of these crops on a single field requires a period of from four to seven years with the following commonly practiced system: First year, corn or beans; second year, corn or beans; third year, oats, barley, rye, or wheat; fourth year, rye or wheat; fifth, sixth, and seventh years, hay. Although this is a long system of rotation and one that would scarcely do if some special crop demanded greater acreage, it has doubtless been one of the chief factors in maintaining the productiveness of the soils.

The plowing is usually done in the fall, the soil being turned to a depth of 6 or 8 inches and allowed to lie in that condition until spring opens, when it is smoothed down with a spring-tooth harrow, pulverizer, or disk. If the soil has become clodded and is difficult to reduce to a good tilth, the roller is also used.

Corn is usually planted between May 20 and June 10. The seed, generally home grown, is dropped in check rows from 3 to 4 feet apart. Cultivation begins with the weeder, which is used until the plants are 4 or 5 inches high. A cultivator is then used from three to five times before the crop is laid by. Harvesting takes place during the latter part of September.

A larger acreage is probably given to the navy bean than to any other crop grown in the area. The beans are drilled in with the corn planter between May 10 and June 10. A slightly firmer seed bed is desired for this crop than for corn, and this is secured by a more thorough harrowing and rolling. The common practice is to leave the surface rolled smooth and hard, but this must result in a considerable loss of moisture by evaporation; and in many cases a hard crust is formed, through which it is difficult for the young plants to break. For these reasons the rolling should be followed by a shallow surface cultivation to form a mulch, which prevents the baking of the surface and also aids in the conservation of moisture. Soon after the beans appear cultivation begins, and the field is cultivated four or five times before the latter part of August. Then, after allowing from two to three weeks for the crop to mature, the plants are cut just beneath the surface with a bean harvester and allowed to remain in small piles in the field until they are dry. As soon as practicable they are placed under shelter to cure, as the crop is often considerably damaged if exposed to rain. When cured, the beans are thrashed and marketed. The hulls and remnants of the vines, together with beans of an inferior quality, which are repurchased from the elevators, are utilized as feed for sheep.

Oats usually follow corn or beans. In preparing the seed bed plowing is sometimes omitted, but usually precedes the work with the disk, drag, or harrow. As early as practicable, in most seasons about the middle of April, the seed is either drilled in or sown broadcast. Drilling usually gives better results, especially in a dry season. Oats are harvested during the latter part of August. As soon as the crop is removed the ground is plowed for wheat or rye. It is then harrowed and rolled to break up the clods. The seed is drilled in about the middle of September, and the crop is harvested in the latter part of the July or early in the August following. Formerly, when wheat was more extensively grown in the county, summer fallowing was commonly practiced.

Timothy and clover seed are usually mixed in the proportion of two-thirds timothy to one-third clover, and are sown with oats. Clover and timothy are included in almost every system of rotation practiced in the area, and a considerable quantity of hay is produced annually. The main hay crop is harvested in July, but a second cutting of clover for seed purposes is usually obtained in September.

The growing of sugar beets is a comparatively new industry in the area, and the methods employed in cultivating the limited acreage now devoted to their production are largely dictated by the agriculturists of the sugar-beet companies. The ground preferably is plowed in the fall and immediately rolled. It is allowed to remain in this condition until spring, when it is thoroughly harrowed and rolled again. Just before planting the seed the field is given another shallow surface cultivation. The seed are drilled in to depths varying from about one-half inch on the heavier to 2 inches on the lighter soils. If the surface becomes hard or crusted, it is loosened again with a drag or fine-tooth harrow to enable the young plants to break through without difficulty. When the beet plants are about two weeks old they are "blocked." This process consists of cutting out all but 2 or 3 inches of beet plants to each foot. The plants are thinned out by hand a short time after blocking and are cultivated frequently thereafter. Great care is necessary to keep the field entirely free from weeds. Beets are harvested in the latter part of September or in October and marketed at the local factories. A large proportion of the beet seed used is imported, but the seed from Washington are said to give a germination test about 20 per cent better than the foreign product.

In addition to the crops enumerated, almost every farmer has a small orchard. This is usually well cared for, and is sown either to bluegrass, field peas, or rape for hog or sheep pasture.

Very little commercial fertilizer is used in the area, but a large quantity of stable manure is applied annually to the oat stubble or sod land. There are a few manure spreaders in use, but the common method is first to distribute the compost in small piles over the field, and then to spread it more evenly over the surface by hand.

Drainage is secured by means of open ditches. These have been constructed at frequent intervals over the more level sections of the area. Tile drainage is not extensively practiced, but it has proved beneficial to the land, not only in wet but also in dry seasons. The idea that tiling the land will make it more susceptible to drought seems frequently to be held by the farmers. Such is not the case, for tiling, by lowering the water table in the soil early in the season, promotes the growth of a deeper root system, and when, later in the season, a drought occurs, the plants draw upon the deeper-lying supply of moisture, and suffer less than would be the case if moisture conditions, such as normally occur in undrained soils, had forced the growth of a shallow root system.

In general, more intensive farming, a more extensive use of tile drainage, and the specialization of crops best adapted to the various soils, are suggested as changes tending to improve the agriculture of the area.

AGRICULTURAL CONDITIONS.

The northern half of Shiawassee County, the area embraced by this survey, is comparatively thickly populated, and is well developed agriculturally. A large proportion of the total area, and especially where the Clyde loam occurs, is continuously under cultivation. The total acreage of farming lands in the entire county is given by the Twelfth Census as 334,895 acres, of which 260,650 acres consisted of improved lands. The soils are productive, and are well adapted to a diversity of crops, which are seldom seriously damaged either by droughts or excessive rainfall. The income derived from profitable yields annually obtained has placed the average farmer of the area in very good financial condition. The prosperous condition of the farming class throughout the area is well illustrated by the general character of the farm buildings. The typical dwelling house is a large two-story frame building, equipped with telephone and other modern conveniences. The outbuildings are neatly constructed and the surroundings well kept, giving to the whole an appearance of thrift and prosperity. The barns in all parts of the area, and especially those recently constructed, are large and generally painted. The practice of stacking the straw or hay and leaving it exposed to the weather during the winter months is going out of general use, and the barns are now being built of sufficient size to afford storage room for the straw, hay, grain, and all other products of the farm, as well as shelter for the stock and farming machinery during the winter months.

The majority of the farmers in the area own the lands they cultivate, but farming lands are occasionally rented for cash or farmed on shares. When a cash rental is paid the average rate is $3 an acre, but the majority of the landholders prefer to rent under the share system. One-third of the crop produced is generally asked when the landlord furnishes the land only, but where he furnishes everything except the labor two-thirds of the crop is taken.

The large tracts of land owned by the earlier settlers have been gradually divided into smaller farms, so that at the present time very few farms in the area exceed 120 acres in extent. There are a few small farms of 40 to 50 acres. The labor conditions of the area make it difficult for any one farmer properly to manage a large tract of land, and the average size of farms for the entire county, as shown by the Twelfth Census, is 89 acres. The larger farms usually contain some areas of small agricultural value, which are used as pasture for the sheep or other stock, but the farms on the Clyde loam and those situated near the principal towns are usually small.

Comparatively little hired labor is employed on the farms of this area, as the average farmer is able, with the aid of his family, to care for the land he cultivates. The farm labor employed is of a very efficient character, and is usually available, except during the harvest season, when it is often difficult to obtain. The average wage by the day ranges from $1 to $1.50, but when hired for longer periods $22 a month with board is usually paid. The large amount of modern farming machinery in use throughout the area greatly reduces the number of laborers needed to carry on the farm work.

Since the early settlement of Shiawassee County wheat has been one of its most important agricultural products. A large yield was always realized, and for years the chief income of the farmer was derived from the sale of this crop. During the past three or four years the yield per acre has been much smaller than formerly, and the result has been a decrease in the acreage. The failure to obtain profitable yields is due both to unfavorable seasons and to the damage done by rust and insects. It is estimated that during the present season (1904) the acreage cultivated to wheat is considerably less than half what it was five years ago. Beans are now the principal money crop of the entire county. The navy bean is extensively cultivated on almost every farm, and profitable yields are obtained on every cultivable type of soil. There is a good demand for this product delivered in the local markets, where it usually brings about $1.25 a bushel.

Although the soils of the area annually give a large per acre yield of corn, the production of this grain is not sufficient to meet the local demands. No corn is shipped to markets outside of the area, and a considerable amount is annually imported from the West. The entire product is fed to stock, a large quantity being used to fatten sheep, which are shipped in from the West, and sent to Buffalo or other Eastern markets as soon as they are in good condition. The oats crop is seldom a failure, and although the larger yields are continuously obtained from the heavier loams, the lighter soils rarely produce less than 25 to 30 bushels per acre. The supply of hay produced greatly exceeds the local demand, and large quantities are annually baled and shipped to distant markets.

The growing of sugar beets, as already noted, is an industry of comparatively recent introduction into the area, and as yet the acreage devoted to their production is not extensive. Soon after the sugar-beet factory was established at Owosso plans were set on foot to introduce the crop throughout the entire county, but the inexperience of the farmers, the high prices paid for labor, and a very unfavorable season caused the experiment to result in a considerable financial loss to the beet growers. This failure greatly discouraged many of the farmers, causing them to abandon the crop, and also deterred many others from attempting its cultivation. However, a small acreage is cultivated to beets in all sections of the area, under the supervision of agriculturists employed by the factory, and there is every indication of a profitable yield during the season of 1904. Enough has been done to demonstrate that the sugar beet can be profitably grown in this part of Michigan, and the prospects are that it will eventually become one of the most important products of the area.

Buckwheat, rye, barley, potatoes, truck, and small fruits are all successfully grown on the various soil types best adapted to them. In 1899 the value of the orchard products alone, as returned for the entire county, amounted to $111,524.

As regards the general adaptation of the soils, the heavier loams are recognized as the soils best adapted to general farming purposes, and the larger yields of wheat, oats, hay, beans, sugar beets, and corn are produced on them. The more sandy soils are well adapted to potatoes, truck, and small fruits. The Clyde loam, owing to its level topography and natural productiveness, is the type best adapted to the growing of sugar beets, and the yield is estimated to be from 1 to 2 tons more per acre than that obtained on the lighter sandy soils or on those occupying the more rolling sections of the area. Potatoes and garden truck are occasionally grown with excellent results, both on the Saginaw sandy loam and on a few of the small, better-drained areas of Muck.

The county roads, connecting the local markets with all sections of the area, are kept in fairly good condition, and iron bridges have been constructed over the Shiawassee River and other principal streams. The four railroads traversing the area furnish adequate facilities for transportation.

Owosso, a city of about 10,000 inhabitants, situated in the southern part of the area, is the principal local market, but Corunna and Durand are also markets of considerable importance. The wheat and oats shipped out of the area go mainly to Detroit and Toledo, while the hay is shipped direct to Boston and other eastern cities. The sheep and hogs go to Buffalo, but the cattle are usually sold at Detroit. A large quantity of beans is annually exported to the larger markets in various sections of the country.

There are several creameries in the county, and these, together with the numerous towns, furnish a ready market for dairy products in all sections of the area.

SOIL SURVEY OF MARSHALL COUNTY, INDIANA.

By **FRANK BENNETT** and **CHARLES W. ELY.**

LOCATION AND BOUNDARIES OF THE AREA.

Marshall County lies in the north-central part of the State of Indiana, only one county—St. Joseph—separating it from the Michigan line. It is bounded on the east by Kosciusko and Elkhart counties, on the south by Fulton County, and on the west by Starke and St. Joseph counties. It contains about 445 square miles. Plymouth, the county seat, situated a little to the west of the center, is 84 miles southeast of Chicago by rail, and 108 miles north of Indianapolis.

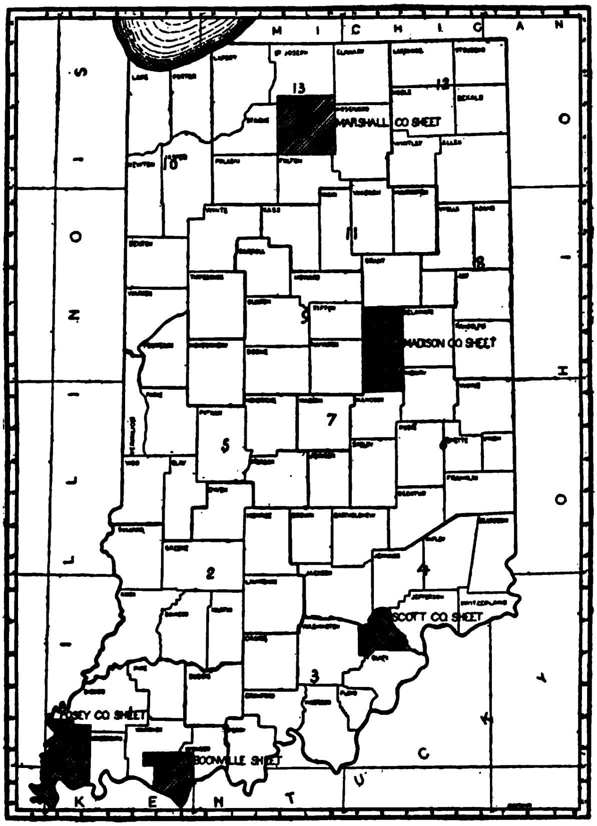

FIG. 28.—Sketch map showing location of the Marshall County area, Indiana.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Prior to the organization of Marshall County this region was inhabited almost exclusively by Potawatomi Indians, who were very numerous here. The first cession of lands now embraced in Marshall County was made by the Indians at a treaty near Rochester, whereby they gave up a strip of land 1 mile in width through the present limits of the county to enable the whites to establish the Michigan road, a highway extending from Indianapolis to Michigan City via Logansport and South Bend. These road lands were offered for sale in 1832 and the proceeds were devoted to the building of the Michigan road, which extends through the center of the county in a north and south direction, following the boundary between the level and the rolling topography of the county.

A few years after the sale of the Michigan road lands most of the lands within the present limits of the county were given up by the Indians, who, after 1838, ceased to be an important factor in the history of Marshall County.

At this time immigrants from Ohio, Pennsylvania, and other Eastern States were rapidly coming into the county, and as the Michigan road was the first one opened, they naturally established themselves in its vicinity. Many of the settlers were Germans, some of whom came direct from the mother country.

The greater part of the county was originally covered with a heavy growth of timber, consisting principally of walnut, oak, and poplar. This timber, except the little that was used for building material, was either burned or destroyed in any possible way to clear the land. As the country became more thickly settled and transportation facilities improved, the lumber business became an important industry in the development of the county. The period from 1860 to 1870 was the most prosperous for this industry.

The first crops grown in Marshall County were corn, wheat, oats, rye, and beans. The soil was prepared by what was known as a "jumping plow" or "breaking shovel," drawn by several yoke of oxen. Grain was sown broadcast and dragged in with a brush. Corn yielded from 25 to 50 bushels per acre. Wheat was frequently a failure, but in favorable years produced from 14 to 18 bushels. Oats were not a great success. Rye was used principally for feed and pasture, rarely being thrashed. Potatoes gave a large yield, and seemed to be of better quality than those produced at the present time. The sandy soils were best adapted to this crop. The early settlers grew a little tame hay, but depended mostly upon marsh hay or corn fodder for their stock feed. When hay was scarce the stock often lived on the buds of the basswood for long periods. Flax was also grown for many years and manufactured into homespun clothing.

About 1865 the farmers began to realize that the soils were becoming less productive, and began to grow clover to maintain their productiveness. Timothy was also introduced about the same time.

When first settled a large part of the county comprised swampy areas, but as it became more thickly settled some attention was given to drainage, though no well-planned system was inaugurated until 1876. Since that time more or less drainage work has been in progress every year, and a great many open ditches and tile drains have been constructed, while the Yellow River, in the northeastern part of the county, has recently been dredged. Many open ditches, into which tile drains empty, are seen in the eastern and northeastern parts of the county. Some of the most productive lands in the county have been made available for agricultural purposes by artificial drainage, and at the present time there is little land that is not well drained, aside from the Muck areas, and in some of the latter drainage work is now in progress.

CLIMATE.

The following table, taken from the records of the Weather Bureau stations at Syracuse and South Bend, shows the mean normal monthly and annual temperature and rainfall. South Bend is about 24 miles north and Syracuse 26 miles northeast of the center of the county.

Normal monthly and annual temperature and precipitation.

Month.	Syracuse.		South Bend.		Month.	Syracuse.		South Bend.	
	Temperature.	Precipitation.	Temperature.	Precipitation.		Temperature.	Precipitation.	Temperature.	Precipitation.
	°F.	*Inches.*	*°F.*	*Inches.*		*°F.*	*Inches.*	*°F.*	*Inches.*
January	25.2	2.47	29.2	2.99	August	72.4	3.19	72.8	3.12
February	24.0	2.32	22.8	2.14	September	63.8	2.76	65.7	2.90
March	34.2	4.00	35.6	2.99	October	54.8	3.55	54.2	2.44
April	50.7	1.93	50.4	1.77	November	40.2	3.74	39.7	3.12
May	62.6	3.77	60.8	3.09	December	27.4	3.07	27.8	3.07
June	69.3	3.60	70.5	2.45	Year	50.0	39.11	50.3	33.65
July	75.4	4.71	74.1	3.57					

The figures show a fairly uniform distribution of rainfall throughout the year, with the maximum during the growing season. The temperature is characterized by sudden changes during the period from October to April, and by alternate freezes and thaws, which sometimes seriously damage crops.

The average date of the last killing frost in spring is April 20, and of the first in fall October 10, giving a growing season of approximately 172 days.

PHYSIOGRAPHY AND GEOLOGY.

The entire area of Marshall County is covered to a great depth by the deposit of drift of the Glacial period. No outcrops of stratified rock are seen, nor have they been reached by any of the many borings. The character of the surface material varies with the topography.

Generally speaking, a line running north and south through the center of the county separates the sandy soils from the clay soils. What are known as the "clay soils" have been mapped as the Marshall loam, which is found principally east of this line. The sandy soils include the Marshall sandy loam, Miami sand, and Marshall sand, and occur west of the dividing line. The topography of the western part of the county is quite rolling, with intervening depressions or slight valleys. Going westward from central points in the county the country assumes a more rolling topography, the bowlder clay being found at greater depths, while the amount of sand increases until finally the "sand barrens" are reached. These barrens, which have been mapped as the Miami sand, seem to be wind-blown deposits and to have some of the characteristics of sand dunes, though in a few places they have the appearance of old beach lines. Some of this sand at the present time is subject to wind action. This sandy region is said to be very similar to that bordering Lake Michigan. The topography of the country along the Yellow River and the lakes is usually very rolling, very little marsh and bottom lands being found. That part of the county lying east of the line above described is level or gently rolling, though there are small areas of a more rolling topography.

There are many basins or depressions in all parts of the county that are locally known as marsh, and have been represented on the map as Muck.

The beds of the streams are usually in the gray or the bluish till, and are covered by a stratum of washed gravel, sand, and bowlders. In many parts of the county bowlders are scattered over the surface. These are chiefly of granite, gneiss, and other metamorphic rocks. From the borings made these rocks seem to be more abundant on the surface than at lower depths.

Many rounded knolls, composed of both stratified and unstratified drift material, appear in different parts of the county. These are most numerous in the Marshall sandy loam.

In many of the gravel pits the stratification is clearly outlined, the material being rounded gravel, clay, and sand, which is extensively used for road construction. Good tile and brick clays are plentiful.

There are many lakes in Marshall County, which are fed from springs that may either flow from the lake basins or along the shore line. The largest and most important of these are Lake Maxinkuckee and Lake of the Woods. The lake bottoms consist of an impervious blue clay, and below this is a mass of sand and gravel from which the springs flow. Marl is sometimes found in the lake beds. There is a large number of flowing wells in the county, these being especially numerous around Lake Maxinkuckee. These have the same source as the springs, being fed from the sand and gravel underlying the blue or gray clay.

The county is drained principally by the Yellow River, which flows across it in a general southwesterly course, though it flows directly west for a distance of about 7 miles just before it leaves the county. Yellow Bank and Pine creeks drain the northwestern corner, while the Tippecanoe River drains the southeastern corner.

SOILS.

The soils of Marshall County have been classified into nine types, including Muck and Meadow. They range in texture from sand to clay loam, and thus offer opportunity for the production of a diversity of crops.

The following table shows the extent of each type, and the map accompanying this report gives the distribution graphically by means of different colors:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Marshall loam	121,216	42.7	**Meadow**	6,784	2.5
Marshall sandy loam	77,184	27.3	**Miami clay loam**	3,392	.8
Miami sand	27,840	9.8	**Miami black clay loam**	1,536	.5
Muck	24,768	8.7	**Miami gravelly sandy loam**	1,216	.8
Marshall sand	20,672	7.4	Total	284,608	....

MARSHALL LOAM.

The Marshall loam, to a depth of 14 inches, consists of a brown loam containing much sand, underlain to a depth of 18 inches by a yellowish-brown loam, which is slightly more tenacious than the surface soil. The subsoil, from 18 inches to 3 feet, is a yellow sticky sandy loam, often containing some gravel.

A few bowlders, sometimes measuring 3 or 4 feet in diameter, and some smaller stones are occasionally scattered over the surface, but the greater part of these has been removed. Large piles are often seen in the fields, and they are sometimes used in constructing fences.

The soil is often heavy enough to form clods, but these are easily broken by the harrow and roller. When put in a good state of tilth the soil becomes a very mellow loam.

There are some small areas where the soil is heavier in texture and darker in color than the typical phase, and often extends to a depth of 18 or 20 inches. The subsoil in such places is a yellowish-drab sandy clay. A small portion of this phase had to be artificially drained before cultivation was a success.

The Marshall loam occupies the largest and most uniform areas of any soil type in the county, though frequently small areas of the other types are found scattered through it. It occupies the greater part of the eastern half of the county, while west of the central dividing line it occurs in comparatively small areas, except in the extreme northwestern corner, where a spur of the main body of the type extend beyond the line.

The Marshall loam is generally level or undulating in topography, though it is found to a slight extent upon rounded knolls and narrow ridges, in which position the soil is often quite gravelly, and stones are scattered here and there over the surface, while the subsoil is a mass of gravel, sand, and clay, which is often used for road material. This phase is not so productive, nor is the soil so deep as that found occupying a more level topography. The average depth of the soil would probably not exceed 8 inches. These knolls and ridges are found chiefly in the small areas of the type occurring in the southwestern part of the county.

In many places along the boundary line between the Marshall loam and the Marshall sandy loam the former has a tendency to become more rolling.

The level areas frequently contain a small amount of gravel, but in no case in sufficient quantities to cause any serious trouble in cultivation. This was most noticeable in German township. Along the northern boundary of this township, which forms part of the county line, the soil had the lightest color of any of the types encountered in the area, and had the survey extended farther north it might have developed into some other type.

The Marshall loam was originally covered with a heavy growth of black walnut, and is still locally known as the "black walnut land." Occasionally a small patch is seen with its original timber, which has been kept as a small forest reserve.

All of this type at the present time has adequate drainage, though tile drainage and other artificial aids were necessary before some of it could be cultivated. The small forest reserves or woodlots are about the only spots not at present under cultivation.

The Marshall loam is generally recognized as the best soil in the county for general farming, being well adapted to nearly all crops grown in the area, and producing larger yields than any other soil type. It is especially adapted to corn, wheat, clover, and timothy.

Corn yields from 35 to 70 bushels per acre, clover and timothy from 1 to 2 tons, and wheat from 15 to 18 bushels.

The following table shows the results of mechanical analyses of typical samples of the fine earth of the Marshall loam:

Mechanical analyses of Marshall loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11970	SE. 40 of NE. ¼ sec. 7, T. 33 N., R. 4 E.	Brown light loam, 0 to 12 inches.	1.1	5.4	9.8	27.6	11.0	28.8	16.2
11972	SE ¼ sec. 19, T. 33 N., R. 3 E.	Brown light loam, 0 to 14 inches.	1.4	12.5	14.9	26.2	4.1	21.6	19.2
11971	Subsoil of 11970	Yellow sticky sandy loam, 12 to 36 inches.	1.9	5.2	8.4	31.1	11.3	25.2	16.5
11973	Subsoil of 11972	Yellow sticky sandy loam, 14 to 36 inches.	2.2	12.5	15.2	27.4	4.5	19.3	18.9

MARSHALL SANDY LOAM.

The soil of the Marshall sandy loam to a depth of 10 inches is a dark or light-brown sandy loam, underlain by a yellow sand to a depth of 20 inches. Immediately below this is found a yellow sandy clay, or in some cases gravelly clay.

This type has usually a rolling topography and generally occurs as irregular ridges composed of rounded knolls. The soil in the intervening depressions is a heavy, black sandy loam, often 18 inches deep, while the subsoil is darker in color than that found on the higher elevations and contains less gravel. Occasionally the subsoil, from 18 to 36 inches, is a heavy, bluish-gray sandy loam. On the rounded knolls the soil is often quite gravelly, and there are many spots of only a few acres which would have been classed as a gravelly loam had they been large enough to represent on the map. The subsoil in these cases often contains such a high percentage of gravel that it is very difficult to make a boring 3 feet deep, and in other places it is almost pure sand and gravel. A few comparatively level areas are seen near the streams, where both the soil and subsoil become quite gravelly. Bowlders, chiefly of granite, are found scattered on the knolls and ridges, and to some extent over all the type, but they are much more plentiful on the knolls. Many small spots of the Miami sand are also found, usually occupying the tops of the ridges, similar to the position of the gravelly phase just described. These spots of sand and gravel are clearly defined during the growing season, as the crops upon them frequently suffer from lack of moisture. The most typical Marshall sandy loam is found on the sides or slopes of the ridges, where the topography is only gently rolling.

The depth to the clayey subsoil varies somewhat, being often 25 inches, which of course accounts for some variation in crop yields.

Probably three-fourths of the Marshall sandy loam is found west of the line heretofore described. The largest area of the type extends north and south through the town of Plymouth, and touches the western boundary of the county in only one place. In the eastern half of the county the greater part of the type lies along the Yellow River and in the southeastern corner of the county.

The Marshall sandy loam, while occurring in broad and somewhat uniform areas, is frequently spotted with the other soil types. It also occurs in small areas in the Marshall loam, which are easily detected by their slight elevation above the adjacent soil.

This type occupies about one-fourth of the area surveyed and is next in importance to the Marshall loam. It is especially adapted to the growing of cucumbers for pickles, and to beans, pease, Irish potatoes, and small fruits. The average yield of cucumbers is about 100 bushels, though 200 bushels per acre have been produced. Corn yields from 25 to 55 bushels, wheat from 12 to 18 bushels, and potatoes from 80 to 170 bushels per acre. Clover and timothy also give fair yields, especially the former.

The following table shows the results of mechanical analyses of the fine earth of both soil and subsoil of this type:

Mechanical analyses of Marshall sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11962	SW. 40 of NW. ¼ sec. 11, T. 32 N., R. 2 E.	Dark light sandy loam, 0 to 15 inches.	0.5	5.3	17.4	48.0	8.8	11.7	7.8
11968	SW. ¼ sec. 29, T. 32 N., R. 1 E.	Brown sandy loam, 0 to 12 inches.	1.7	8.5	14.4	32.2	8.4	21.0	13.6
11963	Subsoil of 11962	Yellow sticky sandy loam, 15 to 36 inches.	2.1	7.0	13.0	37.5	12.2	14.1	13.6
11969	Subsoil of 11968	Yellow sandy clay, 12 to 36 inches.	1.4	5.6	7.3	21.0	9.8	28.5	25.8

MIAMI BLACK CLAY LOAM.

The soil of the Miami black clay loam, to a depth of 8 inches, is a black clay loam having the characteristics of a clay when wet. It is apt to break up into large clods, but unless handled when too wet or too dry can be put into a good state of tilth, becoming quite loamy. The subsoil, from 8 to 36 inches, is a stiff, mottled yellow and blue, or blue clay. Occasionally a considerable amount of sand is found in both soil and subsoil, and a few small gravel are sometimes seen scattered over the surface.

The greater part of the type is under cultivation, though most of it had to be artificially drained to a certain extent before it could be farmed, and there still remains a small portion too wet to give good crop yields. The soil is heavy in texture, and is one of the last to warm up in the spring, yet when well drained it is probably the best corn-producing soil in the county.

The Miami black clay loam is quite limited in extent in Marshall County. It is found only in Bourbon and German townships, most of it in the former, and is distinctly level in topography. Though especially adapted to corn, it is used to some extent for hay and pasture. In good seasons corn yields from 40 to 75 bushels, and hay from 1 to 2 tons, per acre.

The following table shows the results of mechanical analyses of typical samples of this soil:

Mechanical analyses of Miami black clay loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11984	SE. 40 of NW. ¼ sec. 2, T. 34 N., R. 3 E.	Black loam, 0 to 12 inches.	0.7	8.4	19.8	30.2	5.0	14.7	20.7
11986	NW. 40 of NE. ¼ sec. 35, T. 34 N., R. 3 E.	Black clay, 0 to 8 inches.	.1	2.2	4.6	12.2	4.8	36.0	40.6
11985	Subsoil of 11984	Gray sandy clay, 12 to 36 inches.	.4	9.5	19.7	27.8	4.6	12.5	24.9
11987	Subsoil of 11986	Mottled clay, 8 to 36 inches.	.3	2.8	6.2	12.2	2.9	24.5	50.6

MIAMI CLAY LOAM.

The soil of the Miami clay loam, to a depth of 10 inches, is a yellowish-white loam containing between 30 and 40 per cent of sand and the same quantity of silt, underlain to a depth of 16 inches by a yellowish loam containing a lower proportion of sand, beneath which is a yellow silty, sandy, or gravelly clay. The material from 10 to 16 inches is usually somewhat more tenacious than the surface soil. When dry the soil is almost white in color, but when damp it becomes a dark gray.

Most of this type has more or less gravel scattered over the surface and through both soil and subsoil, and in some places it partakes of the nature of a gravelly loam.

The type occupies narrow ridges, usually near lakes or around Muck areas, and is rather rolling in topography, though occasionally a comparatively level area is found. Near the lakes both soil and subsoil are more silty in character, and as a rule there are fewer stones than is the case farther away.

The Miami clay loam occurs in small areas in the western part of the county, only one area being found in the eastern half, near the southern boundary. Erosion has been greater on this soil than on any other within the area.

The type at present is of low agricultural value, but on account of its physical properties it should produce fair crop yields. Some of the more level areas, when carefully cultivated, produce from 25 to 40 bushels of corn per acre, from 14 to 18 bushels of wheat, and good yields of hay. The more hilly portions should produce good bluegrass for pasture and would very likely prove excellent for fruit.

The following table shows the results of mechanical analyses of the fine earth of typical samples of the Miami clay loam:

Mechanical analyses of Miami clay loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11976	SW. ¼, sec. 13, T. 33 N., R. 2 E.	Gray silty loam, 0 to 10 inches.	1.6	4.8	6.9	22.9	8.0	36.2	19.1
11974	¼ mile S. of Lapaz ...	Gray silty loam, 0 to 15 inches.	1.9	5.4	5.8	19.7	10.8	34.9	21.6
11977	Subsoil of 11976	Yellow silty clay, 10 to 36 inches.	1.4	3.5	3.8	12.0	7.4	39.0	33.0
11975	Subsoil of 11974	Yellow silty clay, 15 to 36 inches.	1.4	3.0	3.4	18.0	7.6	32.4	34.1

MIAMI SAND.

The Miami sand, to a depth of 9 inches, is a slightly loamy grayish or yellowish sand of medium texture. The subsoil, from 9 to 36 inches, is a yellow or orange-colored sand of about the same texture as the soil. Practically the only difference between soil and subsoil lies in the organic matter, which gives the former a darker color and more loamy texture, but there are places on the tops of some of the hills where even this difference does not exist. In the depressions the soil is more loamy, much darker, and extends to a greater depth, hence is more productive, than that on the hills.

Practically all of this type is found in the western half of the county, and most of it along the central western border and along the Yellow River and Lake Maxinkuckee. The few small spots found in the eastern half do not cover more than 1½ square miles.

The Miami sand is very rolling in topography, and much of it resembles sand dunes in form and appearance. In all probability a large portion was formerly old sand dunes on which plants have obtained a foothold and checked the action of the wind. Some of it is even now shifted about by the winds.

Probably one-third of the Miami sand is not under cultivation, and some that was once cultivated has apparently been abandoned and left to grow up in weeds. It is the most unproductive soil in the county, but the smaller areas scattered through the more productive types do fairly well, as they have received more attention than the farmers were able to give to the broader areas. Heavy applications of barnyard manure and a careful rotation of crops are absolutely necessary to secure even fair yields from this soil.

More of this type is covered with timber, in proportion to the total area, than of any other soil type in the county. The trees are chiefly scrub oaks, with a few other trees of fair size scattered here and there. The type is locally known as the "sand barrens," and in its extreme phases little agriculture is attempted.

The following table shows the results of mechanical analyses of the Miami sand:

Mechanical analyses of Miami sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11978	NE. ¼ sec. 9, T. 33 N., R. 1 E.	Gray sand, 0 to 8 inches	0.4	6.5	25.2	56.6	5.5	2.1	4.4
11980	SW. ¼ sec. 21, T. 33 N., R. 1 E.	Gray sand, 0 to 10 inches	.8	5.8	18.6	59.9	4.7	4.5	5.0
11981	Subsoil of 11980	Yellow sand, 10 to 36 inches.	.4	5.3	18.9	65.0	4.1	2.7	2.9
11979	Subsoil of 11978	Yellow sand, 8 to 36 inches.	.6	6.2	23.0	59.1	5.3	1.8	3.7

MIAMI GRAVELLY SANDY LOAM.

There is a great variation in the material that forms the Miami gravelly sandy loam, though the soil to a depth of 8 inches is generally a light or dark brown sandy loam, containing a high percentage of gravel and frequently small stones. The subsoil is a gravelly or sandy clay with numerous small stones scattered through it.

The type is found bordering lakes or old lake basins as a chain of rounded knolls or hills, which are generally composed of stratified and unstratified sands, clays, and gravel. One of these knolls may consist almost entirely of sand and gravel, while another near by may be composed of loam or clay; but the brown sandy loam described above predominates, and along the slopes and slight depressions it is comparatively uniform.

The Miami gravelly sandy loam covers only a small portion of the county, the largest area being on the eastern side of Lake Maxinkuckee. Its surface is very rolling and often badly washed. A considerable portion is not cultivated, and on the remainder the crop yields are only fair.

The following table gives the mechanical analyses of the fine earth of this soil:

Mechanical analyses of Miami gravelly sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11954	SW. ¼ sec. 23, T. 32 N., R. 1 E.	Brown gravelly sandy loam, 0 to 10 inches.	4.2	13.4	17.9	35.6	7.5	9.8	11.3
11952	SE. ¼ sec. 30, T. 33 N., R. 3 E.	Gray gravelly sandy loam, 0 to 9 inches.	2.2	10.3	12.7	32.4	9.7	19.2	13.2
11953	Subsoil of 11952	Yellow gravelly sandy loam, 9 to 36 inches.	3.5	11.9	13.1	26.5	7.7	17.4	19.3
11955	Subsoil of 11954	Brown gravelly sandy loam, 10 to 36 inches.	6.5	17.3	15.7	28.2	4.9	7.0	20.2

MARSHALL SAND.

The first 10 inches of the Marshall sand varies from a gray to an almost black loamy sand underlain, usually to a depth of 3 feet or more, by an orange-colored sand or, in places, a sand of lighter color.

Gravel often occurs in both soil and subsoil, and was found in greater quantities in the areas in the southeastern and northwestern corners than in other parts of the county. In the former instance, where the type borders the Tippecanoe River, the presence of gravel has probably been influenced to a certain extent by the river, though at the present time the soil is elevated above all danger of overflow.

The Marshall sand occurs in five comparatively large areas and a few smaller ones. In extent it is about equally divided between the eastern and western sides of the county, and does not occur through the central portion at all. Some spots of the Miami sand, too small to represent on the map, are found in areas of this type, usually as small knolls or sand mounds elevated a few feet above the surrounding soil. A few areas are seen in this type of soil that are lower and flatter than the general type, and here the soil is deeper, darker, and usually more loamy and more productive than the more elevated portions. The subsoil in these cases rests on almost white sand. Frequently at a depth of 8 or 10 feet a blue clay is encountered. As the topography becomes more rolling the soil assumes a lighter color and is of lower agricultural value. The most productive portion of the type is that found in the northwestern corner of the county, but this is more likely due to better cultivation, to more liberal applications of manure, and to a more careful rotation of crops than to any natural difference in the soil itself.

In the western part of the county the type is found associated with the Miami sand, and the line between the two is at times rather indefinite. There is not a great deal of difference between the Miami sand and the Marshall sand so far as texture is concerned, but the latter occupies a more level topography, and there is more organic matter in the soil, making it darker and more loamy. The crop yields are from 10 to 25 per cent higher. The Marshall sand is always lower lying than the Miami sand, and does not have such excessive drainage as the latter; consequently there is less leaching, and the organic matter is retained longer. It is nearly always possible to find water at from 6 to 12 feet below the surface.

The greater part of the Marshall sand is under cultivation. It is best adapted to cucumbers for pickles, beans, and Irish potatoes, though corn, timothy, and wheat are extensively grown, but with only fair yields. Corn yields from 25 to 35 bushels per acre, Irish potatoes from 80 to 150 bushels, and other crops in proportion.

The following table shows the results of mechanical analyses of typical samples of the Marshall sand:

Mechanical analyses of Marshall sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11958	NW. ¼ sec. 28, T. 33 N., R. 1 E.	Brown loamy sand, 0 to 12 inches.	0.4	8.6	30.7	47.4	1.8	5.5	5.8
11956	NW. ¼ sec. 8, T. 34 N., R. 1 E.	Gray medium sand, 0 to 10 inches.	.7	10.7	28.5	45.1	4.2	3.4	6.9
11957	Subsoil of 11956	Yellow medium sand, 10 to 36 inches.	.4	11.7	27.4	48.7	4.6	2.5	4.1
11959	Subsoil of 11958	Yellow sand, 12 to 36 inches.	.2	6.4	28.9	54.9	1.3	1.8	6.1

MUCK.

The Muck in this area usually represents deposits of partly decayed organic matter, sometimes mixed with particles of earth. The Muck areas occupy low, wet places, and are locally spoken of as "marshes." As a rule the Muck is more than 3 feet deep, and there is little change to that depth. Sometimes, however, the surface soil has reached a higher state of oxidation and is a deep black in color, with few, if any, fibers distinguishable, which material gradually changes to a reddish-brown mass, in which the fibers and sometimes the forms of leaves can be made out. In other cases there is no change to a depth of 3 feet. Sometimes the surface is red, especially before cultivation, but becomes black after being plowed and exposed to the air for some time. A few spots are seen in which the mass is very compact or peaty. Around the edges and in other shallow places a whitish sand or sandy clay is found underlying the Muck, but most of that mapped in this county is more than 3 feet deep, though the sand or clay may be found at greater depths.

This type is found in spots from a few acres up to 2 or 3 square miles in extent. It is also seen in narrow strips along streams or at the head of streams, and is always lower than the adjacent soil types, and comparatively level. These small areas of Muck occur in various parts of the county, but the greater portion of the type is seen in the eastern half.

Owing to the position of some of the Muck areas, it is supposed that they are old lake beds, which have gradually become filled with decaying organic matter. A few instances are seen where Muck entirely surrounds a lake, which is much smaller now than it was at one time. Sometimes where the ground is springy and wet on the slopes the Muck extends a short distance up the slopes; otherwise it is very level. It is naturally covered with swamp grass, goldenrod, huckleberry bushes, and cottonwoods, with occasional larger trees. Before cultivation small mounds about 1 foot in height are often seen thickly scattered over the surface.

In its natural condition water is always near the surface, and artificial drainage is necessary before cultivated crops can be grown, except in some instances around the edges. Drainage has been accomplished to some extent by constructing large, open ditches into which tile drains empty, and much work is being done at the present time along this line. About 75 per cent of the type is yet undrained.

Until drained the Muck can be used only for pasture and for hay, but when drained it is an almost ideal soil for onions and celery, and good crops of corn can also be secured. Some onions are grown at the present time. Corn is the most common crop on the drained areas, the yields ranging from 40 to 75 bushels per acre. Marsh and timothy hay are the chief crops on the undrained areas, yielding from 1 to 3 tons per acre, generally of a poor quality. The greater part of the type is used chiefly for pasture.

MEADOW.

The term Meadow represents poorly drained areas along streams and in depressions, which are not usually cultivated. The soil may consist of a heterogeneous mass of material, though it is usually a heavy black sandy loam, rich in organic matter. The subsoil varies from a tenacious blue clay to a white sand.

The material composing the type is much more variable along streams than in depressions, this being due to stream action. The soil bordering the streams is often almost pure sand and gravel, but in other places the first few inches is muck. When found in depressions, the soil is rather uniform and usually has the characteristics of the sandy loam described above.

Most of the cultivated areas of Meadow are found in these depressions, which have been wholly or partially drained. Corn is the principal crop, but these areas are rarely cultivated, except around the edges. The type is used mostly for grazing or hay.

AGRICULTURAL CONDITIONS.

The farmers of Marshall County are in a fairly prosperous condition. In the eastern half of the county, which is largely occupied by the Marshall loam, nearly every acre of which can be cultivated, the farmers as a rule are more prosperous than those living on the sandy soils in the extreme western portion. The houses, though often small, are nearly always painted, and the barns are of sufficient size to shelter all the live stock and machinery. Many silos are also seen. As a rule, the houses are smaller and not quite so good on the more sandy soils, and a good dwelling with no barn is frequently seen.

The value of farm land ranges from $20 to $100 an acre. The Marshall loam is generally held at from $65 to $100, the Marshall sandy loam at from $65 to $75, the Marshall sand at from $30 to $40 when in cultivation, and other lands at from $20 to $60 an acre. Muck undrained sells at from $20 to $30, and when drained at from $40 to $70 an acre.

About 75 per cent of the land in this county is under cultivation or in a condition to be cultivated. The remainder consists of sand, marshes, timber land, and rough broken land, and, aside from the marshes, the greater part of this land lies in the western half of the county. Much of this uncultivated land can be used for pasture, so that there is comparatively little land in the county from which some returns can not be secured.

About $2,000,000 in mortgages is held against the farms of Marshall County, which is between 15 and 25 per cent of their value. While these farm mortgages apply generally throughout the county and are not confined to any one soil type, yet they are fewer in proportion to the total number in the northern and northeastern parts of the county than in other sections. A great many German farmers live in those parts of the area, and, being of industrious and prudent habits, they have maintained a better financial standing.

About 60 per cent of the farms are operated by the owners. The remainder are cultivated by tenants, who pay a rental of from two-fifths to one-half of the crop made, or, very rarely, a cash rent, which ranges from $3 to $4.50 an acre. The proportion of grain paid varies in different sections. For corn lands one-half of the crop is more often paid, while for wheat and rye either two-fifths or one-half is paid, according to the amount of seed furnished and the proportion of the thrashing bill paid by the owner and tenant, respectively.

About 90 acres is the average size of farms in this county. Where onions and potatoes are grown the farms are below the average in size, but where much live stock is kept they are usually larger. There are several farms of 640 or more acres, but as a rule these large holdings are divided up and rented in smaller tracts.

The smaller farms are generally operated by the owner or tenant and his family, assisted to some extent by labor hired by the day or week during harvest and other pressing seasons. The wealthier farmers usually hire by the month, paying from $20 to $25 and board, and employing the men from the 1st of March to the 1st of November. The harvest season is from June 15 to August 15, during which time there is a great demand for laborers, and efficient men receive from $1.75 to $2 a day. At other times day laborers receive $1.25 a day and dinner. During the corn-husking season labor is much in demand, and at times farmers find difficulty in getting the crop out as fast as they desire. The labor is exclusively white and is usually efficient, but the supply is often inadequate.

Corn and wheat are the principal products of Marshall County. From 15 to 25 per cent of the cultivated lands is planted to each of these grains. The average yield of corn in the county is 35 bushels per acre and of wheat 10 bushels. Winter wheat only is grown. Owing to severe damage to wheat by freezing and by the Hessian fly, there has been a tendency in recent years to reduce the acreage somewhat and to give more attention to the growing of rye, but as yet rye is an unimportant crop. The corn is planted in checked rows and cultivated with two-horse machinery. A great part of it is cut for fodder, both by hand and by corn binders and binders and shockers.

The fodder is sometimes shredded, and thus prepared it may be substituted for hay. A part of the crop is put into the silo and utilized in that way. Wheat is generally sown in drills, and is thrashed either in the field or at the barn. Clover is an important crop, about 15,000 acres being cut every year. It is generally sown with wheat or oats, and produces two crops, one of hay and one of seed, a considerable proportion of the seed being shipped out of the county. Timothy is grown on all soils except the sand, and will thrive in low, damp places where clover or corn does not do well. Both clover and timothy hay are baled and shipped to eastern markets. Oats are grown largely for home use, but some are shipped.

Among the minor crops cucumbers are probably the most important. They are grown chiefly on the more sandy soils and are sold at the salting stations, of which there are seven within the area. The managers of these stations contract with the farmers, giving them 60 cents a bushel and providing the seed. Cucumbers are rarely grown in large fields, the patches ranging from 2 to 5 acres. Onions are grown chiefly on the muck and potatoes on the more sandy soils. On nearly every farm there is an orchard, which supplies the needs of the owner. A great many apples are made into cider, to be sold later as vinegar.

Except on the most sandy land every farmer keeps one or more milch cows. A great many sell milk to the creameries, of which there are several within the area. According to the census of 1900 the value of dairy products in Marshall County was $163,028. A great many beef cattle, hogs, and sheep are kept also, this being more particularly true in the eastern half of the county. The Shorthorns, Angus, and Herefords are the chief breeds of cattle, and the Chester Whites, Poland Chinas, and Berkshires are the breeds of hogs most in favor. Almost the entire grain crop produced in some sections of the Marshall loam is consumed upon the farm. The raising of live stock is to be commended, for the more manure produced the more productive the lands should become. Increased interest is being shown in the live-stock industry.

The farmers of Marshall County have a fair understanding of the adaptation of soils to crops. The Marshall loam is generally recognized as the best soil in the county for general farming and the more sandy soils as best for the special crops. The possibilities of the Marshall sandy loam and the Marshall sand for Irish potatoes, however, are not fully appreciated, especially in the case of the latter type of soil, which produces fair yields of corn and rye, but is excellently adapted to potatoes, which, with liberal applications of manure, give very large yields. It is suggested that where the type lies near Muck areas a dressing of the Muck would prove very beneficial.

Marshall County is well supplied with railroad facilities. The Baltimore and Ohio crosses the northern part of the county in an east and west direction; the Pittsburg, Fort Wayne and Chicago the central part; the New York, Chicago and St. Louis the southern part; the Lake Erie and Western the western half in a northwest and southeast direction, and the Logansport division of the Terre Haute and Indianapolis passes through the southwestern, central, and northern parts of the county. Few points in the area are more than 7 miles by wagon road from a station. The three east and west lines are trunk lines from Chicago to the East, so that all produce can be quickly shipped either way from any point in the county.

Good dirt roads are found on nearly every section line, and many of them have been graveled. Except in the most sandy areas there is rarely any difficulty in getting products to market.

Plymouth, the largest town in the county, had a population in 1900 of 3,656. Other smaller towns are Bremen, Bourbon, Argos, and Culver. Only a comparatively small portion of the produce can be consumed within the county, so that it is necessary to seek larger markets. Plymouth is only 84 miles from Chicago by rail; but as this large western market is supplied with enormous shipments from all over the northern part of the Mississippi Valley, the farmers of Marshall County find better markets elsewhere. Some of the products are shipped to the larger towns around the State, while a great deal of live stock, hay, etc., is shipped to Pittsburg and Buffalo. Nearly every railroad station in the county has an elevator, and the exceptionally good railroad facilities enable the farmers to send their products wherever they may desire.

SOIL SURVEY OF SCOTT COUNTY, INDIANA.

By **A. W. MANGUM** and **N. P. NEILL.**

LOCATION AND BOUNDARIES OF THE AREA.

The extreme dimensions of Scott County are 17 miles from east to west and 15 miles from north to south. The county is bounded on the north by Jackson and Jennings counties, being separated from them by the Muscatatuck River, on the east by Jefferson County, on the south by Clark and Washington counties, and on the west by Washington and Jackson counties. The total area included within these boundaries is 126,336 acres, or approximately 197 square miles.

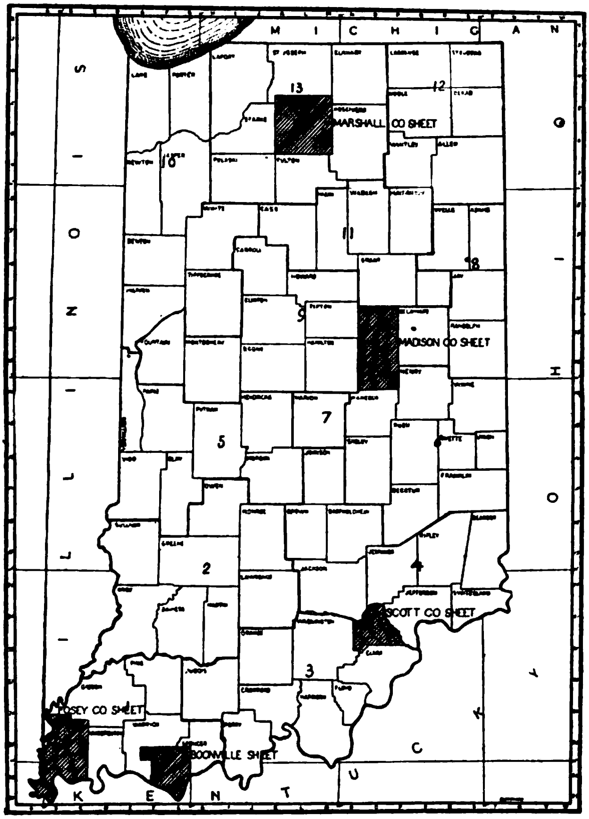

FIG. 29.—Sketch map showing location of the Scott County area, Indiana.

Scottsburg, the county seat, is situated on the main line of the Pennsylvania Railroad, which runs between Chicago and Louisville, and affords an excellent shipping point to some of the large cities. The population of Scottsburg is about 1,200. Prior to 1885 lumbering was the chief occupation, but since that date agriculture has become the leading pursuit of the people.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Few events of any importance in the history of Scott County transpired before the war of 1812. Several attempts had been made prior to that time to establish settlements in this part of Indiana, but they were generally unsuccessful on account of trouble with the hostile Indians. The Pigeon Roost settlement, which was established in the southern part of the area in 1809, was probably the first settlement of any importance in the county, but this was attacked in 1812 by Indians, most of its inhabitants massacred, and the village completely destroyed. The Indians, however, were soon defeated and driven from this part of the State, and settlement then progressed more rapidly. A few foreigners, chiefly Irish, Scotch, and Germans, were among these early settlers, but the majority came from Kentucky, Tennessee, North Carolina, and Virginia. Scott County was organized in 1817. The county seat was at first located at Lexington, but was later transferred to Scottsburg.

Considering the length of time the county has been settled, its agricultural development has been very slow. The early settlers cultivated small tracts of land to corn, wheat, potatoes, and other general farm crops for home use, but they depended on the timber of the surrounding forests as their main source of income. Larger areas were put under cultivation and more interest was taken in tilling the soil as the land became cleared and the lumber industry declined. About 1850 a railroad, now a part of the Pennsylvania system, was built through the county, and fourteen years later the Baltimore and Ohio Southwestern was constructed. Later on these roads aided materially in the development of the county, as they afforded excellent facilities for transporting its products to eastern markets.

The eastern part of the area was the first to develop agriculturally. The timber in this part of the county was of much lighter growth than was found on the low, flat valleys farther west. The soil was productive and easily cultivated, and its topography rendered it better adapted to general farming purposes than the rough, broken country of the southwestern part of the area.

About 1880 the lumber industry began to fail, and by 1885 it had become of minor importance. This marked the beginning of the real agricultural progress of the county, and farming soon became the

leading occupation of the people. The agricultur
county is estimated to have increased fully 50 per
last twelve years. Corn, wheat, oats, clover, tim
tables are now successfully grown on almost every t
county, and the rough and hilly sections seem
orchards and vineyards. Within the last few yea
ing has developed into a very important indust
acreage is annually devoted to the production of t
have been established in the county a number of c
which afford a ready market for all the tomatoes
specialization of this crop is proving very profitable.

Great interest is manifested in the county agricu
tions and in the subject of good roads. Within the
considerable attention has been paid to road constr
of the streams are now spanned by durable iron brid

Although there was practically no increase in th
Scott County during the twenty years from 1880 to
progress during the last fifteen years has been very
phone system connects the rural districts with the citi
free delivery of mail has been established. Tile drai
ough cultivation of the soils, and more modern met
are rapidly coming into use, and the county as a w
prosperous condition.

CLIMATE.

The following table, compiled from Weather
shows the normal monthly and annual temperature a
taken at Scottsburg, within the county; at Madis
County, just east of the area surveyed, and at Salem
County, just west of the area.

Normal monthly and annual temperature and preci

Month.	Scottsburg.		Madison.	
	Temperature.	Precipitation.	Temperature.	Preci tatio
	°F.	Inches.	°F.	Inche
January	32.9	3.28	34.2	4.
February	31.0	2.60	31.5	2.
March	43.2	4.44	43.9	4.
April	52.8	2.31	55.6	3.
May	65.0	3.70	65.3	4.
June	74.4	4.30	74.9	4.
July	78.0	3.02	77.9	3.
August	76.4	2.90	76.3	3.
September	69.1	2.38	70.2	2.
October	57.5	2.18	58.1	2.
November	44.5	3.43	44.8	3.
December	36.3	3.25	35.1	3.
Year	55.1	37.74	55.7	40.

These three places are practically in the same latitude, but it will be noticed from the above table that the precipitation is somewhat greater at Madison and Salem than it is at Scottsburg, while the annual temperature is about the same.

The average for these stations may be taken to represent conditions in the county. The rainfall is usually ample for all the crops grown.

PHYSIOGRAPHY AND GEOLOGY.[a]

There have been two controlling factors in the physiographic development of Scott County—the limestone, sandstone, and arenaceous shale of the Knobstone group and the black, slaty shale of the New Albany series. The upper strata of the Knobstone group, which cap the hills in the southwestern part of the county, have resisted the agencies of erosion better than the softer underlying shale, and the surface of this section is very broken and hilly. The shales belonging to the New Albany series, which underlie the soils of the eastern two-thirds of the county, have given rise to a rolling topography.

The Knobstone hills of the southwestern part of the area have an elevation of from 200 to 400 feet above the drainage level of the country north and east of them, and present the most prominent topographic features of the area. These hills have been cut by numerous northward-flowing streams, which have formed deep, narrow, V-shaped valleys, varying in length from 1 to 5 miles. As the streams approach the more rolling country the valleys become much broader and the slope of the hills is more gentle. The surface of these broader valleys was once much lower than it is now, as there has been a silting up of the stream beds since the formation of the valleys until the material deposited is estimated in many cases to exceed a depth of 20 feet.

The level upland parts of the county are best developed west of Scottsburg and in the vicinity of Austin. Here the surface is comparatively level, although it is traversed by many small streams and shallow valleys. The streams flow across these uplands in a general northern direction, and the shallow valleys vary in width from a few rods to about 1 mile.

As already pointed out, the topography of the eastern two-thirds of the area is of a gently rolling character. The summits of the rounded hills are comparatively level, and the hillsides slope gently toward the small streams which flow through the broad, intervening valleys. Along the lower stretches of the streams the valleys have been gradually filled up with sediment, and the neighboring hills are lower and more gently undulating. This characteristic is especially well developed just east of Scottsburg and along Stuckers Fork and its larger tributaries, where material has been deposited to a depth of many feet.

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[a] The statements in regard to the geological formations of the area are based upon data given in the Twenty-sixth Annual Report of the Indiana Geological Survey.

In the extreme northern part of the county the topography retains its rolling or undulating character, but the general elevation is much less than it is farther south. The land bordering the Muscatatuck River, in the northwestern part of the area, is low and flat, but marked by many old stream channels, bayous, narrow sloughs, and low, sandy ridges. It has only a slight elevation above the level of the stream, and is subject to frequent overflow during the heavy spring rains. A narrow, sandy ridge, generally a few feet higher than the greater part of this flood plain, extends along the immediate banks of the river, and is not so much subject to overflow as the lower lands farther back from the stream.

However, most of the area has good natural drainage. The rough and hilly country in the southwestern part of the county is drained by the Big Ox Fork and its tributaries. This stream flows across the county in a general northward direction, and empties into the Muscatatuck River. Pigeon Roost Creek, which also has its source in the Knobstone hills, traverses the south central part of the area and empties into Stuckers Fork. The latter stream and its main tributaries, Kimberlins Creek and Big Hog Creek, drain the greater part of the rolling uplands in the eastern and central parts of the area.

The Muscatatuck River, which forms part of the northern and northwestern boundaries of the county, is the principal stream of the area, and receives the drainage waters of almost the entire county.

The approximate glacial boundary of southern Indiana takes in the northeastern two-thirds of Scott County. It is difficult to determine its exact limit, but the ice sheet is thought to have extended to the Knobstone hills. Although it is believed that a considerable proportion of the surface material covering the greater part of the county is of glacial origin, it is very probable that the material was mainly of local derivation, as no glacial bowlders or fragments of igneous rocks are encountered in the soil.

The geological formations which underlie the area are frequently exposed on the steeper slopes and are seldom at any great depth below the surface. The shales weather rapidly on exposure, and have undoubtedly entered largely into the composition of the various types of soil. The eastern part of the area, including the territory covered by the Volusia silt loam, is underlain by the New Albany black shale, and small, partially decomposed fragments of this rock are frequently encountered in the lower part of the soil section and in the subsoil. These shales, which here form the highest member of the Devonian age, are, in the extreme eastern part of the area, only a few feet thick. They have, however, a general dip to the southwest, and at Scottsburg, in the central part of the county, they attain an estimated thickness of over 120 feet.

A thin layer of limestone, known as the Rockford goniatite limestone, which forms the lowest member of the Lower Carboniferous, sometimes occurs overlying the New Albany black shales, but it has had little, if any, influence on the composition of the soils. Above this layer of limestone, or where the stratum is absent, lying upon the New Albany shales, is a series composed of argillaceous and arenaceous shales and thin layers of sandstone, which belongs to the Knobstone group of the Lower Carboniferous.

The New Providence shales, which occur at the bottom of this group, consist of a soft clay shale of greenish or bluish color. They are estimated to be about 50 feet thick at the southern boundary of the county, but gradually become thinner toward the north. In the northern part of the area it is difficult to distinguish these shales from those occurring just above them. They weather rapidly on exposure and have probably entered into the composition of the soil, though not to so great an extent as the series overlying them.

The Upper Knobstone shales occur just above the New Providence series. They are of a light-gray or greenish color, and grade from a soft argillaceous shale at the botton to a sandy shale and impure, fine-grained sandstone at the top. Above these shales and forming the upper series of the Knobstone group are alternate layers of more or less pure sandstone and sandy shales. This series is known as the Knobstone sandstone and varies in thickness from about 75 to 100 feet. It occurs capping the higher elevations in the southwestern part of the county, and does not weather so rapidly as the softer shales of the lower series. Embedded in the strata are considerable quantities of iron concretions, which impart a reddish color to the derived soils.

The surface material of the area is, in the main, so similar to that formed by the disintegration of the underlying geological formations that it is difficult to determine what proportion of the soils is derived from material reworked by glacial agencies and what proportion has been derived directly from the decomposition of the rocks.

SOILS.

Four types of soil occur in Scott County. Of these, three are derived from the weathering of the underlying geological formations and glacial deposits. The fourth, occurring in the low, flat bottom lands, is derived from material deposited by the streams, together

with that which has been washed down from the surrour
The following table shows the extent of each of the fou

Areas of different soils.

Soil.
Volusia silt loam
Scottsburg silt loam
Dekalb silt loam
Waverly silt loam
Total

SCOTTSBURG SILT LOAM.

The Scottsburg silt loam consists of a light to very li
silt loam, having an average depth of 8 or 10 inches. S
cretions are scattered over the surface and through the
frequently a considerable amount of fine and very fir
with the silt, which causes the soil to have many of the
of a fine sandy loam. At 10 or 12 inches the soil grade
yellow or slightly mottled silt loam. This becomes gra
and more compact as the depth increases, and at 30 to
sists of a heavy silt loam of a drab or gray color, slightl
yellow iron stains and usually containing small iro
This soil resembles the Miami silt loam, but the color is

This type of soil occurs in areas of greater or less ex
all parts of the county. A large area is found just we
of Scottsburg, occupying that part of the uplands lyin
hills of the southwestern section and the rolling uplan
ern part of the area. In the eastern and northeastern
county the areas gradually become smaller, and finall
the small level areas capping the summits of the rolling
which do not exceed a few acres in extent.

The entire area embraced by this type has the gener
of having once been a level upland plateau, but it is n
by many small streams with wide, shallow valleys. Tl
of the broad areas between these streams is flat or very
and the slope toward the small watercourses is seldom s
cause the lands to suffer to any great extent from erosior
raphy of the small areas occupying the summits of th
east and north of Scottsburg is also comparatively level
slopes of the rounded hills are usually occupied by th
loam.

The numerous small streams that traverse these sectio
are adequate to carry off the excess water at times of he

the type, as a whole, is fairly well drained. Tile drains are seldom used, but a good system of underdrainage has proved of great benefit to this soil wherever it has been established, both in wet and dry seasons. The crops cultivated on this soil are often considerably damaged by droughts, and the better results are nearly always obtained during seasons when the rainfall is greatest.

The areas included in this soil type are underlain by the soft argillaceous and sandy shale of the Knobstone series. However, as this section of the area is thought to be within that part of Indiana which was at one time covered by glaciers, it is very probable that a considerable part of the material from which this soil has been formed was deposited through glacial action. As no bowlders or igneous rocks occur in these areas, this glacial material would seem to be chiefly of local origin. The soft underlying shales disintegrate very rapidly wherever they have become exposed, and also have undoubtedly entered largely into the composition of the soil.

Very careful management is necessary to keep this soil in a productive state, and some system of crop rotation is very important, as the continued cultivation of any one crop soon decreases the yields. In order continually to obtain good results, the turning under at least once in every two or three years of clover or some other crop that adds considerable humus to the soil is very essential.

The Scottsburg silt loam is cultivated to corn, wheat, oats, clover, timothy, and tomatoes, and often produces yields equal to those obtained on any other soil type in the area; but when no rotation is practiced and the land has been poorly cultivated, small yields are secured. When properly cultivated corn yields about 30 bushels per acre. Wheat will average 12 to 15 bushels per acre. Oats, when sown in the spring, average about 25 to 30 bushels, but when put in during the fall months much larger yields are obtained, provided the crop escapes winter killing. Clover and timothy produce about 1½ tons of hay per acre, while the yield of clover seed ranges from 1½ to 3 bushels per acre.

This type of soil seems best adapted to tomatoes, small fruits, vegetables, and all early-maturing crops adapted to the climatic conditions of the area. The constant cultivation of the soil necessary in the growing of tomatoes seems to benefit these lands, but if cultivated when in a wet condition the soil dries out rapidly and bakes into clods, and it is difficult to reduce these again to a state of good tilth.

Alfalfa has been successfully grown on limited areas, and experiments have proved that a very fair grade of tobacco can also be produced on this type.

The table following gives the results of mechanical analyses of samples of this soil.

Mechanical analyses of Scottsburg silt loam.

No.	Locality.	Description	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11003	3½ miles NE. of Scottsburg.	Silty loam, 0 to 12 inches.	0.9	3.3	4.1	9.3	9.7	61.8	10.8
11011	2 miles W. of Scottsburg.	Silty loam, 0 to 12 inches.	1.5	2.2	1.7	3.3	6.2	72.7	11.9
11009	1 mile W. of Austin.	Silty loam, 0 to 14 inches.	1.9	4.9	3.8	6.7	8.8	57.6	16.4
11010	Subsoil of 11009......	Silty loam, 14 to 36 inches.	1.6	3.6	3.1	5.6	8.3	59.6	17.9
11012	Subsoil of 11011......	Silty loam, 12 to 36 inches.	.3	1.0	.9	2.2	8.4	69.4	18.0
11004	Subsoil of 11003......	Gray silty loam, 12 to 36 inches.	.8	2.1	2.5	5.9	7.4	59.4	21.8

DEKALB SILT LOAM.

The Dekalb silt loam, to a depth of 10 inches, is a silty loam of a gray to light-brown color, becoming light red or yellow at greater depths. The soil is easily eroded and the texture varies slightly according to the steepness of the slopes and the consequent degree of erosion that has taken place. On the steeper hillsides much of the finer material has been washed down to the lower levels and the underlying yellow or red heavy silty loam has become mixed with the coarser material, forming a soil of a more pronounced red to brown color, containing less fine sand.

The subsoil is a heavy reddish to yellow silt loam containing a small proportion of fine sand. It rapidly becomes heavier as the depth increases, and at 30 to 36 inches is a very heavy silt or clay loam, still containing some fine sand, but of a stiff, tenacious character.

Small fragments of chert, limestone, and sandstone are frequently encountered, both on the surface and in the soil. These are the remains of the upper strata of the Knobstone group, which once extended over this part of the area.

The Dekalb silt loam occurs in one large, unbroken area, embracing the whole of the extreme southwestern portion of the county, and extending for some distance along its southern boundary. The topography of the country occupied by this soil is rough and broken. The small streams have cut rapidly through the soft shale, forming deep, narrow valleys. The upper strata of the Knobstone shale and sandstone have not weathered so rapidly as the softer shale beds, and still cap the higher elevations, making the general topographic features consist of a series of isolated knobs and irregular ridges, separated by deep, narrow ravines. The stream valleys widen out as they approach the more level country to the north and east, and the steep, precipitous banks disappear as the adjoining hills become low and more rounded.

Pigeon Creek and Ox Fork have their sources in this part of the area, and these, together with their many small tributaries, furnish the natural drainage system for the surrounding uplands. The land is often excessively drained, and in order to obtain the best results methods for conserving the soil moisture and for protecting the lands against erosion must be used.

Glaciation is thought to have extended to the foothills of the rough and broken country occupied by the greater part of this soil type, and it is very probable that there was a deposition of the finer glacial material over a considerable part of this section of the county. A large percentage of the material from which this soil is formed is derived, however, from the disintegration of the Knobstone shale. As already stated, small fragments of limestone, chert, and sandy shale are often encountered, scattered on the surface and mixed with the soil; and the soft blue argillaceous shale, containing numerous layers of impure chert and flat, oblong, cherty concretions, is frequently found at a very slight depth below the surface. Thin layers of hard brown ferruginous shale, such as form the outer layers of the embedded geodes and ironstone concretions, frequently occur associated with the softer shale or scattered in small fragments on the surface. The characteristic red or yellow color of the soil is due to the oxidation of the large amount of iron contained in the material from which it is formed.

Many of the hillsides, where the topography is most broken, are too steep to be profitably cultivated, and as a whole less of this type of soil has been developed agriculturally than any other soil in the area; but the greater part of these cultivated lands produces very fair yields of corn, oats, wheat, rye, timothy, clover, and tomatoes.

Crops maturing in the late summer often suffer from drought, but under careful cultivation the average yields per acre will compare favorably with those obtained from any of the upland soils. Corn produces, on an average, 25 bushels; wheat, 10 to 15 bushels; and oats, about 20 bushels per acre. Clover and timothy yield from 1½ to 3 tons per acre, and a large quantity of clover seed is thrashed each season, the crop averaging about 2 bushels per acre. Tomatoes are extensively cultivated and yield an average of 6 tons per acre. The less hilly areas occupied by this type of soil are well adapted to wheat, clover, oats, tomatoes, and timothy, while the rough and hilly sections are well suited to fruit. Large yields of peaches and apples have been continually realized from the small orchards situated on these lands, but many of the trees have recently been injured by disease—a form of leaf blight—which has lessened the crop yields considerably. The thriving condition of a few small vineyards indicates that this soil is excellently adapted to grapes and might be profitably employed for their production on a commercial scale.

The following table gives the results of mechanical analyses of the fine earth of samples of this soil:

Mechanical analyses of Dekalb silt loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
10983	2 miles SW. of Leota.	Silty loam, 0 to 12 inches.	0.9	2.9	3.7	13.0	12.1	54.2	13.1
10981	Sec. 13, T. 2 N., R. 6 E.	Silty loam, 0 to 18 inches.	.7	2.8	3.6	7.6	7.2	63.4	14.7
10985	1 mile W. of Leota ..	Silty loam, 0 to 14 inches.	.3	1.1	1.3	3.0	4.2	66.5	23.5
10984	Subsoil of 10983	Loam, 12 to 36 inches.....	1.5	3.8	4.8	16.1	12.3	37.9	23.6
10982	Subsoil of 10981	Heavy silty loam, 18 to 36 inches.	1.2	2.3	7.3	9.9	7.7	47.3	24.2
10986	Subsoil of 10985	Silty loam, 14 to 36 inches.	.2	1.6	1.4	3.2	5.2	62.8	24.8

WAVERLY SILT LOAM.

The soil of the Waverly silt loam has an average depth of 8 to 10 inches and consists of a gray to light-brown silty loam, which becomes slightly heavier as the depth increases. It contains varying amounts of medium to fine sand and a large quantity of small iron concretions mixed with the soil and scattered over the surface. The soil grades into a heavy silty subsoil of a drab color, usually mottled with yellow iron stains. The sand content of the subsoil decreases with depth and at 36 inches the material is a heavy mottled silty or clay loam, containing a small amount of sand and a large quantity of small rounded iron concretions.

While a typical section of this soil as it occurs over the greater part of the low bottom lands will show a gray to light-brown silty loam containing varying amounts of sand, the texture of the soil is often modified to a considerable extent by local conditions. The areas extending along the smaller streams are influenced by the different geological formations through which the streams have cut their channels and by material washed from the surrounding uplands. Areas of this phase of the soil, such as the one found at the junction of Stuckers Fork and Hog Creek, are usually better drained than much of the type and are not so subject to overflow as the greater part of the bottom lands. The sand content often varies considerably, the texture of the surface soil frequently ranging from sandy to silty within areas less than an acre in extent. These local variations, occurring along the smaller streams in the more rolling parts of the county, are not of sufficient extent to permit the classification of each modification as a separate soil type.

The largest areas of the Waverly silt loam form what is known locally as "The Flats"—an area bordering the Muscatatuck River. The type also extends in strips of varied width up the shallow valleys of the other principal streams and their tributaries.

These low flat areas have a very gently rolling or level topography. Occasionally a narrow ridge extends along the immediate banks of the river, and this has an elevation a few feet higher than that of the greater portion of the flat bottoms, while small sandy areas, usually less than an acre in extent, are frequently encountered along the stream. Numerous sloughs, narrow ponds or bayous, old stream beds, and swampy depressions are found scattered over this part of the county. The soil found in these depressions forms the heavier phase of the Waverly silt loam. On drying the surface becomes baked and sun-cracked, causing the soil to be more difficult to cultivate properly than the higher and more sandy areas.

The low-lying position which the Waverly silt loam occupies and the many basinlike depressions lying between the streams and the rolling uplands make the natural drainage very poor. The streams which traverse this type have a very slight fall, and during the heavy spring rains they leave their channels and spread out over the adjoining bottoms. These streams have cut their channels to a sufficient depth below the level of the lands bordering them to admit of ditching and tile draining, and where this is done the lands are in a condition to cultivate soon after the spring floods have subsided. Many of the lower depressions and narrow sloughs would be difficult to drain, but a good system of tile drainage would greatly enhance the agricultural value of the greater portion of this type.

The Waverly silt loam has been formed from material deposited by the streams at times of overflow, mingled in places with material washed down from the surrounding uplands. The coarser material held in suspension by the streams is deposited during overflows near the banks of the main channels, while the silt, clay, and finer sand particles are laid down where the current is more sluggish. The sandy texture of the low ridges that occur near the streams is due to the sorting of the material by currents of varying velocities; but those areas lying nearer the rolling uplands owe their sandy character to material washed down from the neighboring hills. The areas of this type occupying the narrow valleys nearer the sources of the small streams are not as frequently overflowed as the broad, flat valleys near the river, and the soil here owes its origin more to the erosion of the steeper hillsides than to material laid down by the streams during times of overflow.

The agricultural value of these bottom lands depends to a marked degree on the thoroughness of the drainage. The better drained areas along the river and those occupying the valleys in the rolling uplands produce excellent yields of all crops cultivated, while the poorly drained areas in the low depressions, when cultivated at all, are devoted to the production of timothy and other grasses. Where the soil is well drained and properly cultivated, corn produces an average yield of 45 bushels per acre, and 50 to 60 bushels is not an uncommon yield during a favorable season. Wheat produces from 18 to 20 bushels per acre, but is not extensively sown, owing to the liability of the crop to destruction during the spring floods. Twenty-five bushels per acre is the estimated average yield of oats, but owing to the usually wet condition of these lands during the early spring months oats are seldom grown. Tomatoes on the better-drained areas yield about 6 tons per acre. Timothy produces 2½ to 3 tons of hay per acre, and clover also does well, especially on the low ridges.

The soil is well adapted to corn and timothy. The corn crop is usually planted after the annual spring floods have subsided and is seldom a failure. Timothy always produces a profitable yield of hay, and is successfully grown on the poorly drained areas. A comparatively large proportion of these flat bottom lands is still covered with a heavy growth of hardwood timber—oak, hickory, and beech.

The straightening of the channels of many of the small streams, a more extensive use of tile drains, and the removal of driftwood and other obstructions from the channels of the larger streams would greatly improve the conditions over much of this soil and increase its value for general agricultural purposes.

The following table gives the results of mechanical analyses of typical samples of the soil and subsoil of the Waverly silt loam.

Mechanical analyses of Waverly silt loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10999	Sec. 13, T. 4 N., R. 6 E.	Silt loam, 0 to 8 inches	1.2	2.2	1.1	3.4	5.6	67.6	18.5
10997	Sec. 7, T. 4 N., R. 7 E.	Silt loam, 0 to 10 inches	.2	.6	.4	3.2	7.0	70.0	18.7
10995	2 miles E. of Scottsburg.	Heavy clay loam, 0 to 8 inches.	.4	1.3	1.0	3.2	5.2	51.5	37.4
10998	Subsoil of 10997	Heavy silty loam, 10 to 36 inches.	.4	.8	.5	2.2	11.2	66.8	17.9
11000	Subsoil of 10999	Heavy silty loam, 8 to 36 inches.	1.1	2.6	1.3	3.0	4.3	66.9	20.7
10996	Subsoil of 10995	Gray clay loam, 8 to 36 inches.	.5	1.0	.7	2.5	6.9	54.1	34.1

VOLUSIA SILT LOAM.

The Volusia silt loam is the most important upland soil in the area. It covers the greatest extent of territory and is recognized as well adapted to general farming purposes. The best developed and most profitable farms in the area are situated on this type.

The soil is a light-brown silty loam, often containing considerable fine sand. When dry the surface has a gray appearance, but the color changes to light brown or red as the subsoil is approached. The soil has an average depth of 8 to 10 inches, and the texture becomes slightly heavier with increased depth. Small iron concretions occur both on the surface and throughout the soil. The soil grades into a subsoil of light-red to yellow heavy silt loam, containing a small percentage of sand and rapidly becoming heavier and stiffer as the depth increases, until in the lower 10 or 12 inches of the profile is found a heavy silt loam, stiff and compact, but seldom containing a sufficient amount of clay to give it a sticky or tenacious character. As the underlying shale is approached the material becomes yet more stiff and compact, and at from 4 to 5 feet below the surface it is a very heavy silt or clay loam, with a very low sand content.

The Volusia silt loam covers the greater proportion of the eastern part of the county. Approached from the west, it first appears as narrow areas extending along the steeper slopes of the rounded hills, but these areas rapidly broaden out and finally cover the entire rolling upland, except where the Scottsburg silt loam occurs capping the higher elevations.

The topography of this type of soil is quite rolling. The hills are low and rounded and slope gently to the broad, shallow stream valleys. In the extreme eastern and northeastern sections the surface is slightly more broken, the hillsides are steeper, and the intervening valleys become narrow and V-shaped. These steeper slopes suffer greatly from erosion, and the red or yellow silt loam of the upper subsoil is frequently exposed on the surface, or has been washed down and mixed with the soils occupying the lower levels, giving the latter a red to brown tinge.

These lands are very well drained by the natural drainage system furnished by the rolling topography and numerous small streams—are frequently too well drained, in fact, for the successful cultivation of many crops.

It is generally believed by geologists who have made a study of this area that the glacier once covered the section of Scott County occupied by the Volusia silt loam, and that a deposit of glacial drift was laid down over the older geological formations. The material composing this soil contains no glacial bowlders or other evidence of having been transported from other localities by glacial agencies, and the drift seems to be mainly of local origin. The black shale, which is encountered at a depth of from 3 to 30 feet below the surface, forms by disintegration a light-brown to red silty material similar to that found in the overlying soil. This shale is frequently exposed in cuts and along the steeper hillsides, and has entered largely into the composition of the soil. The shale has embedded in it a large quantity of rounded iron concretions, and it is probably to the weathering of these that the derived material owes its red or yellow color.

In the central part of the county the Volusia silt loam is found along the steeper hillsides, where the erosion has been greatest and where outcrops of the underlying shale are frequently encountered.

During a season of average rainfall and where the soil has not suffered from the effects of erosion profitable yields of corn, wheat, oats, clover, timothy, and tomatoes are produced. Corn yields from 30 to 35 bushels; wheat, 15 to 20 bushels; oats, about 25 bushels, and clover, 1 to 2 tons of hay and about 2½ bushels of seed per acre. Timothy is not as extensively grown on this soil as on some of the other upland types, but will yield about 1½ tons of hay per acre. The yield of tomatoes is about 6 tons per acre.

There are a few farms on this soil which give larger yields than the above year after year. The difference is due to more thorough cultivation, a rotation of crops, and more careful soil management generally. Potatoes and other vegetables are grown on this soil to a limited extent for the local markets, and excellent yields are obtained. In general, the soil of this type is well adapted to general farming, and all crops cultivated in the area can be successfully grown upon it.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Volusia silt loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10993	2¼ miles S. of Lexington.	Brown silty loam, 0 to 12 inches.	0.5	2.8	7.0	6.3	4.2	67.5	11.6
10989	4¼ miles E. of Scottsburg.	Brown silty loam, 0 to 18 inches.	1.9	3.5	3.4	7.3	8.2	60.2	14.9
10991	2 miles NE. of Lexington.	Silty loam, 0 to 10 inches.	.5	2.1	3.0	7.4	6.7	62.6	17.7
10990	Subsoil of 10989	Heavy silty loam, 18 to 36 inches.	1.7	3.4	2.6	5.3	6.4	60.5	20.1
10994	Subsoil of 10993	Heavy silty loam, 12 to 36 inches.	.3	1.8	2.8	3.3	4.3	63.5	23.8
10992	Subsoil of 10991	Clay loam, 10 to 36 inches.	.6	2.3	3.0	7.1	8.5	50.9	27.5

AGRICULTURAL METHODS.

A large amount of commercial fertilizer is applied annually to the soils of Scott County, but where modern and improved methods of farming are in use the soils retain their productivity and profitable yields are continuously obtained with the application of a minimum amount of fertilizer.

Some system of crop rotation is necessary on all the soils of the area in order to obtain good results, and rotation, which has been practiced for some time by the more successful farmers, is now coming into general use. The wheat lands are usually plowed in the late summer or early fall and are rolled and harrowed from three to four times before the wheat is drilled in. The crop is sown during September or October and is harvested about July 1. Oats are often cultivated in much the same manner, but when drilled in during the fall months a profitable yield is very uncertain. If the winter is unusually mild, larger yields are often obtained from the winter oats than from those drilled in during the spring months, but the uncertainty involved in this method causes it to be seldom practiced. The oats crop is put in as early in the spring as the usual wet condition of the soil permits. The lands are given a rather shallow plowing, and then harrowed and dragged. After the seed is put in the fields are again harrowed.

In growing corn and tomatoes level cultivation is not generally practiced, but where this method has been used on the upland the best results have been obtained, as the soils retain a larger amount of moisture and the crops suffer less from the effects of the summer drought. The lands cultivated to corn are plowed as early as the season permits. The fields are then harrowed and dragged till the clods are broken up and the soil is in a thoroughly pulverized condition. The fields are usually "checked off" by shallow furrows crossing each other at right angles, so that the crop may be cultivated both ways. Corn is planted from the latter part of April to the first of June and is harvested in September. The soil is prepared for the tomato crop in much the same way as for corn. The tomato seed is first sown in beds about the last of March, and the young plants are taken up and set out by hand during the latter part of May or early in June. Level cultivation for this crop, especially where grown on the Scottsburg silt loam, has been very successfully practiced.

The agricultural value of the poorly drained areas occupying the flat lowlands along the more important streams has in many places been greatly increased by the establishment of a good system of tile drainage. The greater part of these lands has a sufficient elevation above the level of the streams to permit tile to be laid from

3 to 4 feet below the surface and still have a sufficient fall to the stream to insure good drainage. The average cost per acre for tiling these lowlands is estimated at about $18.

Clover is extensively cultivated on the steeper hillsides of the rolling uplands as a means of checking the excessive erosion to which these soils are subject. Where the greater part of the upper soil has been washed down to the lower levels, leaving the subsoil exposed on the surface, an application of barnyard manure is often necessary in order to get a stand.

AGRICULTURAL CONDITIONS.

As pointed out in the paragraphs devoted to the history of the county, its agricultural development has progressed very slowly, and it is only in recent years that the cultivation of the land has received the whole attention of the farming class. The area was originally covered by a heavy growth of timber, and the principal occupation of the rural population was the cutting of timber for crossties and staves. As the lands were cleared and the timber became less plentiful more interest was taken in farming, and within the last fifteen or twenty years the condition of the farming class has steadily improved and the value of cleared lands has greatly increased. Few of the farmers in the area are wealthy, but the majority are practically free from debt, and as a whole are in a very prosperous condition. The introduction of crop rotation and other improved methods of farming, together with a demand for the general farm products at good prices, have been the principal causes of the present favorable status of the agricultural class, which is most marked in the eastern part of the county, where the lands have been longer under cultivation and the people have depended for a longer period on the products of the farm rather than on those of the forest as their principal source of income.

About 64 per cent of the farms in Scott County are operated by the owners. The remainder are rented, either for a share of the products or for cash. The owners of the farms on the low river flats also own and cultivate small areas in the neighboring uplands, where they make their homes. The swampy condition of the lowlands and the fact that they are subject to annual overflow make it undesirable to live in this section of the area.

There are a few large landholders in the county who cultivate farms of several hundred acres, but the average size of the farms is approximately 89 acres. The total area in farms is about 113,578 acres, over half of which is at present improved.

Aside from those owning land, the farmers of Scott County are either renters or " tenants " on the farms of the larger landholders.

The "tenant" receives a fixed sum, usually about $25 a month, and is entitled to no part of the crop produced. The landowner furnishes the land, farm buildings, work animals, farming machinery, seed, and fertilizers, and receives the entire crop yield. Lands are seldom rented on a cash basis except in small tracts for the production of tomatoes, in which case the rate varies from $3 to $10 an acre. When rented on shares the owner furnishes only the land and farm buildings and receives one-third to one-half of the corn, wheat, and oats, and three-fifths of the clover and timothy produced.

An excellent class of white labor was once abundant throughout the county, but in recent years, as the agricultural interests of the county have rapidly developed, the demand for intelligent farm hands has greatly increased, and efficient labor is often scarce during harvest. The wages paid during the harvest season range from $1 to $1.50 a day, but when employed by the month or for longer periods the average farm laborer receives about $20 a month and board.

The principal products of Scott County are corn, wheat, oats, timothy, clover, and tomatoes. A small acreage is also cultivated to potatoes and other vegetables. In 1900 the total corn crop was estimated at 407,920 bushels, being an average yield of about 23 bushels per acre for the entire acreage in that crop. The corn crop is seldom a failure, either on the uplands or river flats, and where a good system of rotation is practiced a very profitable yield is always obtained on any of the soil types of the area. Wheat is extensively cultivated over the entire upland section of the county, and, although the acreage devoted to this crop has decreased in the last three years, it is still more widely cultivated than any other crop produced in the area, with the exception of corn. In many localities the wheat crop during the past two or three seasons has been almost a total failure. This has been due to the damage done by the Hessian fly and rust. The result has been a decrease in the acreage devoted to wheat and an increase in the acreage of oats and rye.

Both clover and timothy are successfully grown in all sections of the county, each yielding annually from 5,000 to 7,000 tons of hay. Clover is always included in the crop rotation practiced on the rolling uplands, as it aids materially in checking the excessive erosion common to this portion of the area, and in restoring the lands to their former state of productiveness.

The growing of tomatoes has become one of the most important special industries of the county, and the number of acres cultivated to this crop is yearly increasing. In the county there are six canning factories, which are supplied by the surrounding country. The annual output of each factory is estimated at about 400,000 cans.

A large number of hogs are raised in the county, and a few farmers own a sufficient number to enable them to ship carload lots to the more distant markets. Very few cattle, however, are raised for shipment, and the small shipments sent to the larger markets are usually gathered from all parts of the county. The raising of poultry for shipment to the eastern cities is at present a very profitable industry throughout the county, and large quantities of both chickens and eggs are annually sent out.

The Waverly silt loam is the principal corn soil of the county, as, owing to its annual flooded condition, a profitable yield of any of the other staple crops is very uncertain. The corn crop is planted late in the spring and is less liable to damage by floods than wheat or oats. The annual deposition of new material over these lands during periods of inundation, together with that washed from the surrounding hills, causes them to suffer very little if any from the continuous cultivation of one crop.

Wheat, oats, rye, and clover are well adapted to the Volusia silt loam, and if properly cultivated produce large and profitable yields. These crops are also successfully grown on the more rolling sections of the Dekalb silt loam, and in a wet season or on small areas where the drainage is not excessive they will produce yields equal to those obtained on any other soil type of the area. The rougher and more broken section of the Dekalb silt loam is best suited to apples, peaches, and grapes. There are at present a few small vineyards in this part of the county, and there has been a ready market for their products. The small orchards have received very little attention, and although large yields are annually obtained, no attempts have been made to raise fruit for other than the local market.

Timothy is extensively grown on the poorly drained areas of the Waverly silt loam and produces larger yields than are obtained on the uplands.

The tomato seems best suited to the Scottsburg silt loam. While the growth of the plant is not as vigorous as on some of the lowland soils, a larger yield per acre is always realized.

Alfalfa has been successfully grown, both on the level uplands and stream bottoms, but no attempts have been made to cultivate more than a few small isolated areas to this crop. Sorghum cane has also been grown as a forage crop on some of the soils and excellent results have been realized.

A small amount of tobacco, chiefly of the heavy export type, has been raised in the county, and the yield and price obtained for the crop indicate that its production could be made a very profitable industry in the area.

Two railroads enter the county, one traversing the west-central and the other the eastern part. These furnish a means of rapidly transporting the products of the county to markets situated at a distance.

No section of the county is more than 6 to 8 miles distant from a local shipping point on one or the other of these railroads.

A well-kept system of public roads extends over the county, connecting Scottsburg, Austin, and Lexington, the most important shipping points, with all sections of the surrounding country. Many of these roads are constructed from the hard black shale and limestone which underlie the eastern part of the county, and traffic over them is seldom impeded even during the worst seasons of the year. Iron bridges have also been constructed over the small streams on every important county road.

Scottsburg and Lexington are the local markets for most of the products of the county. The corn not consumed by the local hominy factories is marketed at Cincinnati or Indianapolis, while the wheat and other products exported are shipped to Cincinnati, Chicago, Louisville, and Indianapolis. The entire crop of tomatoes is taken by the local canning factories.

The situation of the area near many of the largest markets and the shipping facilities afforded by the railroads permit those products of the area that are not consumed at home to be placed on the markets in the larger cities in a short time and at a very small cost, and this fact favors the extension of other special crops, such, for instance, as the fruits already indicated as suited to certain soil conditions, but at present produced only on a small scale.

SOIL SURVEY OF THE BOONVILLE AREA, INDIANA.

By A. W. MANGUM and N. P. NEILL.

LOCATION AND BOUNDARIES OF THE AREA.

The Boonville area is located in the southwestern part of Indiana, bordering on the Ohio River. It is bounded on the east by the meridian of 87° west longitude and the Ohio River; on the north by a line drawn east and west through Tennyson; on the west by a

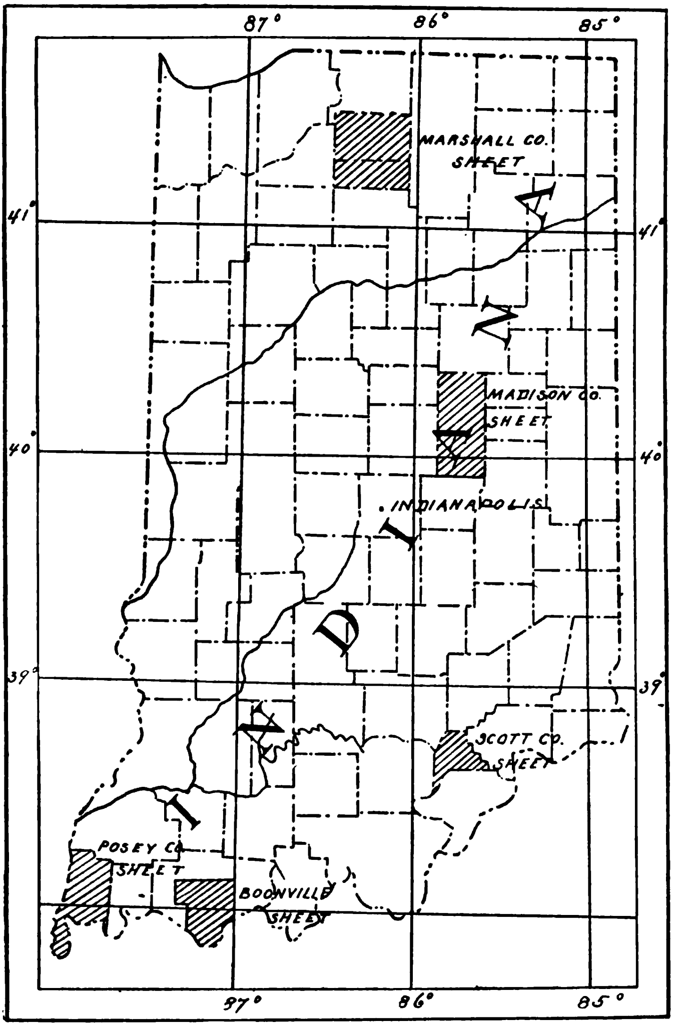

FIG. 80.—Sketch map showing location of the Boonville area, Indiana.

line running 10¾ miles north from the Ohio River to 1¾ miles east of the village of Hatfield, thence west for a distance of 4¾ miles, and then north to the northern boundary; and on the south by the Ohio River. This territory includes parts of Warrick and Spencer counties, and embraces 169,216 acres, or approximately 264 square miles.

The area is well adapted to agriculture, which, together with the coal industry, forms the leading occupation of the people.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

In 1803 John Sprinkle crossed the Ohio River from Kentucky and settled at Newburg, Warrick County, and in the same year a few other families followed him, taking up the adjoining lands. These first settlers were all known as "squatters," as the county was not surveyed until 1805, and it was some years after that date before these lands were put on sale by the Government. Four years after the settlement at Newburg the present town of Rockport was established by Daniel Grass, and as supplies for the settlement were easily obtained from Owensboro, Ky., its population rapidly increased. The settlement of the area was at first slow, on account of frequent trouble with hostile Indians, but after the battle of Tippecanoe, in 1811, which effectually destroyed all chance of future annoyance from that source, the population of both the inland section and that along the river increased very rapidly. Many settlers came in from Kentucky, Tennessee, Georgia, Virginia, and the Carolinas, as well as from the States to the east.

The development of the northern part of the area progressed more slowly than that of the section which bordered on the river, because there was no outlet for its products and communication with the outside world was much more difficult. All supplies were taken from the river to Boonville in wagons until the railroad reached that town, in 1873.

At first the settlers cultivated only small areas of corn, grain, and potatoes for home use, depending on the game in the surrounding forests for meat and on trading with the boats which passed up and down the river for all other necessaries of life. The growing of tobacco began to attract attention soon after the area was settled, and later, when good markets for the product were established at Owensboro and Louisville, Ky., its production rapidly increased. Corn, tobacco, wheat, barley, and oats soon began to be cultivated on a comparatively large scale, and gristmills were erected, so that the people no longer depended on Kentucky as a source of supplies.

About 1836 two agricultural societies were organized, one at Rockport and one at Boonville, for the purpose of encouraging the farmers of the area in stock raising and the cultivation of general farm products. County fairs and farmers' institutes were held yearly, where a small number of stock and a few other products of the surrounding country were exhibited; but no great interest was taken in these attempts until 1856, when a new organization was formed, which continued for years to be the most prosperous agricultural society in the State.

Corn and tobacco continue to be the leading products of the area. A tobacco market was established at Rockport in 1855. The high prices prevailing during the decade from 1860 to 1870 caused a great increase in the tobacco acreage. The supply from the Southern States was cut off during this period, and there was a great demand for tobacco at high prices. The acreage devoted to this crop increased so rapidly that tobacco was soon cultivated almost to the exclusion of all other crops. Spencer County alone is said to have produced as much as 10,000,000 pounds a year. In more recent years the production of tobacco has greatly decreased, but at the present time the prices offered at the neighboring markets of Owensboro and Louisville are causing renewed interest in its cultivation.

One of the most important factors in the development of the northern portion of the area was the advent of the Lake Erie, Evansville and Southwestern Railroad, which reached Boonville in 1873. This afforded adequate means of transporting the products of this section to both the local markets and those situated at a distance from the area. The coal deposits in the immediate neighborhood soon began to be developed, which caused a large increase in population and property values. It had been known for some time that there were coal beds in the hilly sections of the area, but owing to the lack of transportation facilities no attempt had been made to develop them. During the last ten years coal mining has attained considerable local importance, and coal is now being shipped to more distant markets.

The area at the present time is well developed agriculturally. It contains a number of towns and villages, of which Boonville and Rockport are the largest, each having a population of about 3,000. They have a number of small factories and are the centers of trade for large and prosperous rural districts.

CLIMATE.

The area surveyed is not subject to severe winters or to excessive heat during the summer months. The winters are not only mild, but of comparatively short duration. The growing season comprises about six months of the year, during which time crops are safe from damage by frosts. There is usually adequate rainfall for the crops grown, and injury from drought is very uncommon, even to crops maturing in the late summer.

During the early part of the spring excessive rains, occurring both in this State and those to the northeast, together with the melting of the snows farther north, cause the Ohio River to overflow. Large areas of the flat, low lands along its course are flooded, rendering them too wet for the early cultivation of crops.

The last killing frost in the spring usually occurs about April 9, and the first in fall about October 31.

The following table shows the normal monthly and annual temperature and precipitation as observed at Evansville, Ind., which is situated only a short distance southwest of the area:

Normal monthly and annual temperature and precipitation.

Month.	Evansville.		Month.	Evansville.	
	Temperature.	Precipitation.		Temperature.	Precipitation.
	° F.	*Inches.*		*° F.*	*Inches.*
January	35.4	3.31	August	78.4	2.09
February	32.3	2.98	September	71.9	2.48
March	44.6	4.84	October	59.2	2.87
April	57.0	3.55	November	45.0	3.67
May	67.0	4.38	December	35.8	3.02
June	76.3	4.67	Year	56.9	41.40
July	79.6	3.54			

PHYSIOGRAPHY AND GEOLOGY.

The physiographic features of the area are quite marked, varying from rolling uplands and small valleys to bottom lands or river flats. The rolling uplands vary considerably in height, but rarely exceed 500 feet above sea level. The coal knobs, located 3½ miles northwest of Rockport, have an elevation of 600 feet and are the highest hills in the area. The hilliest portions are found in the vicinity of Boonville, in the northwestern corner of the sheet, around Chrisney, in the northern and eastern portions of the area, and to the south and west of Rockport.

The hills in only a few instances have very steep slopes, but as a rule are characterized by their smooth, gently rounded forms, with intervening shallow depressions. At Rockport, where the hills extend to the river, they have a steep, precipitous bluff, 75 to 100 feet above the level of the river, for about 2 miles to the south of that town. Where the surface is undulating or less hilly the soil does not erode to any extent. It is only on the steep sides of some of the higher hills that erosion is very great.

The principal valleys of the area occur along the Cypress Creek Ditch and Little Pigeon Creek, which still flow in the same channels they occupied prior to the Glacial period.

The valley formed by the Cypress Creek ditch has an average width of 1 mile and extends across the area from north to south immediately west of Boonville. The Little Pigeon Creek Valley traverses the area in a northeast and southwest direction and occupies the territory between the Boonville hills on the west and the Chrisney hills on the east. It has an average width of 4 miles and is the largest valley in the area. Numerous other small valleys occur, especially in the hills, where small streams have cut their way through, but they are not of sufficient importance to warrant separate discussion. The streams usually overflow after heavy rains or long wet periods, and the soils found in the valleys are of a silty or clayey character.

The surface of the bottom lands or river flats in the southern part of the area, along the Ohio River, presents a flood plain, cut by numerous small streams, old stream channels, and bayous. These lands are flooded annually by the overflow of the river, and each year new channels and bayous are formed. A few small ridges occur over these bottoms and have an elevation of 3 to 4 feet above the surrounding surface. The elevation of this flood plain is from 340 to 360 feet above sea level.

Following the course of the Ohio River and bordering it is a sand ridge, averaging one-half mile in width, which is somewhat higher than the lands immediately back of it and is rarely overflowed. The soils found in the bottoms are of a stiff clayey character, and owing to their low-lying position are exceedingly difficult to drain.

All the drainage of the Boonville area finds its way into the Ohio River, the streams flowing in a southerly direction and emptying directly into the river. The largest is Little Pigeon Creek, which drains over three-fourths of the area. It enters the area 2 miles east of Tennyson, flows in a southwesterly direction, and passes out about 5 miles west of Richland City. The Cypress Creek ditch, which flows in a southerly direction through the extreme western portion of the area, drains the territory around Boonville and to the west of it. The remainder of the area is drained by smaller streams, which have their sources within the area and flow directly into the Ohio River.

The rocks forming the basal structure of the area belong to the Carboniferous system. The rocks of this system have played an important part in the economic geology of the area, and at present quite extensive coal mines are being developed. The rocks belonging to this period which are more commonly exposed consist of sandstone, shale, and shaly sandstone. Exposures may be seen in different parts of the area, especially in deep road cuts.

Inasmuch as the underlying rocks are everywhere covered by a thick mantle of loess they have played only a minor part in the formation of the soils of the area. During early Quaternary times great ice sheets extended across Indiana some distance north of the area.

As the ice melted and the glaciers began to recede it is believed that a part of the material which later formed the soils of the area was released and carried still farther south and deposited over broad flats by streams then issuing from the glacial front. It was later picked up by the winds and generally redeposited in the form of loess over the surface of the uplands, covering all older geological formations. The soils of the bottom lands are of recent alluvial origin, being made up of reworked loess material and very fine sand, and are generally underlain by alluvium of the Glacial age.

SOILS.

The soils of the area are divided naturally into two general groups—upland and bottom land. The several soils, in their typical occurrence, are quite distinct, each possessing its own physical peculiarities. Six types have been recognized in the area, the Miami silt loam and Miami fine sandy loam being found in the upland division; the Waverly silt loam, Waverly clay loam, Waverly clay, and Waverly fine sandy loam in the bottom-land division of the area.

The following table shows the actual and relative extent of each of the different types found in the area:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Miami silt loam	86,656	51.2	Waverly clay	8,320	4.9
Waverly clay loam	30,208	17.9	Waverly fine sandy loam	3,904	2.3
Miami fine sandy loam	22,848	13.5	Total	169,216	
Waverly silt loam	17,280	10.2			

MIAMI SILT LOAM.

The Miami silt loam is the most extensive type in the area surveyed. Its topographic features, ability to withstand drought, adaptability to a great diversity of crops, and its natural productiveness make it the most valuable soil in the area for general farming purposes.

The soil is a silt loam averaging from 8 to 10 inches in depth, and varying in color from a light ashy gray to light brown, according to the amount of organic matter present. It contains, in its typical form, a small percentage of fine sand, and when recently put under cultivation or in its virgin state carries a large amount of organic matter.

The subsoil, from 9 to 36 inches, consists of a silt loam containing a small proportion of very fine sand in the first few inches. It varies in color from dark red to yellow, and becomes heavier as the depth increases. At a depth of 4 or 5 feet the clay content is much larger and a very heavy silt loam occurs, which is usually of lighter color than that immediately underlying the soil. The material is very compact at a depth of from 25 to 36 inches, making a subsoil very retentive of moisture, while the fine silty texture of the soil prevents the surface from becoming baked, sun cracked, or difficult to cultivate.

The Miami silt loam, covering 51 per cent of the entire survey, occurs in the uplands in all parts of the area. The largest unbroken body occurs in the northeastern part of the area and extends from near Rockport to the extreme northern boundary. Small tracts occupy the low ridges in the vicinity of the flat river bottoms. These differ slightly from the typical Miami silt loam in that the soil is slightly heavier and the underlying subsoil has a larger clay content. These small areas have undoubtedly been submerged at times, and the soil has been slightly altered by material deposited by water, as well as by that washed down from the neighboring uplands.

The topography of the country occupied by this type is rolling. The hills are low and rounded, with gently sloping sides, and the intervening valleys are broad and shallow. This insures good drainage, and with proper attention the land is subject to but little injury from erosion. Artificial drainage is seldom necessary and is practiced in but few localities, the rolling topography being usually sufficient to drain the excess water into the numerous small streams.

The loess from which this soil is derived is of glacial origin. The material, which is supposed to have been transported by wind and water, was deposited as a mantle over the entire country to the southward. It shows no stratification, and has an average depth of from 8 to 10 feet in the more hilly section, although it often reaches a greater depth in the valleys or more level areas. The loess overlies beds of sandstone and shaly sandstone belonging to the Carboniferous system. These rocks, however, have not entered into the composition of the soil, except on an occasional steep slope where a thin layer of sandy shales has been exposed through the process of erosion, in which case they weather rapidly, and, becoming mixed with the silty material, cause a larger percentage of fine sand in the soil of the immediate vicinity.

Great care is necessary to keep the Miami silt loam in a high state of productiveness, and a rotation of crops is very essential in order to secure the best results. Where the soil is in a loose and thorough state of cultivation, as is necessary when the crop is corn or potatoes, it suffers greatly from the effects of erosion and large areas of the subsoil are exposed along the steeper slopes.

The Miami silt loam is well adapted to most of the general farm products of the area. Wheat and oats do especially well and large yields of clover, timothy, and other grasses are always obtained. Very little tobacco is cultivated on this type, as the other soils of the area are considered better suited to the variety grown in this section. Wheat averages 15 bushels, oats about 30 bushels, and corn from 30 to 35 bushels per acre. Where the soil is well tilled and a good system of rotation practiced, much larger yields are frequently realized without the aid of commercial fertilizers. Clover and timothy average from 1½ to 2 tons per acre, two or more cuttings often being obtained. Apples, peaches, plums, and pears are all successfully grown in the more hilly sections. No attempt has been made to cultivate vegetables and truck crops, except on a limited scale for home use and for local markets, but excellent yields are generally realized from these crops.

The following table gives the mechanical analyses of typical samples of the Miami silt loam:

Mechanical analyses of Miami silt loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10796	1 mile E. of Pedigo Lake Mills.	Gray to brown silty loam, 0 to 12 inches.	0.1	0.3	0.2	0.5	4.0	84.2	10.7
10798	¼ mile S. of Chrisney.	Yellow to brown silty loam, 0 to 10 inches.	.2	.8	.5	1.2	6.1	77.1	13.8
10797	Subsoil of 10796	Heavy silty loam, 12 to 36 inches.	.0	.2	.1	.3	8.7	68.2	22.4
10799	Subsoil of 10798	Yellow silty loam, 10 to 36 inches.	.2	.3	.4	.7	5.2	70.2	22.7

MIAMI FINE SANDY LOAM.

Third in extent and second in agricultural importance among the soil types of the Boonville area is the Miami fine sandy loam. The soil consists of a light to dark brown fine sandy loam, averaging about 8 inches in depth. This sandy loam varies from fine to medium in texture, with the coarser material usually occurring in the upper portions of the soil. The sand content rapidly decreases with depth, and below 8 to 14 inches the subsoil is a heavy fine sandy loam, whose color varies from light red to yellow, generally becoming lighter in the deeper layers. The subsoil found from 20 to 36 inches below the surface is a light silt or clay loam, there being only a small percentage of sand present.

The type is practically uniform throughout the area, with the exception of a few minor variations in local spots. On some of the higher elevations a sandy phase occurs which consists of a very sandy loam in which the percentage of sand continues to be quite large throughout the entire 3-foot profile. At a lower depth, however, the sand content decreases rapidly, and at 4 or 5 feet below the surface the subsoil is the same as that found underlying the typical soil. The sandy loam of this phase, for a depth of from 20 to 30 inches, is somewhat coarser than that of the typical soil, but grades rapidly into a sandy loam of finer texture at lower depths.

In low positions a somewhat heavier phase of the type is encountered which has been slightly modified by the action of water. The soil in this case is a fine sandy loam to a depth averaging 8 inches, mixed with varying quantities of organic matter. The underlying subsoil is a heavy fine sandy loam which grades into a clay loam at about 15 to 20 inches below the surface. The color of both soil and subsoil varies from gray to brown, depending upon the amount of organic matter present. These variations occur only in limited areas over the main soil type, and are not of sufficient extent to be shown on a map of the scale used.

The Miami fine sandy loam occurs in one extensive body, reaching from the central part to the southwestern corner of the area. It embraces all the territory from a short distance south of Midway southwest to within three-fourths of a mile of the Ohio River. The eastern boundary of this area is formed by the rolling uplands of the Miami silt loam and the western by the bottoms of Little Pigeon Creek. Two small patches of this type are found a few miles northwest of Rockport, bordering the bottom lands of Lake Drain Creek. In the extreme western part of the area, northwest of Hatfield, two small areas are also found.

The topography of this soil is generally level or slightly undulating. Some portions, however, consist of low hills with shallow depressions intervening. The small hills or ridges trend in a northeast-southwest direction, the general slope being to the south and west.

Many small streams and drains flow across this type in a southwesterly to westerly direction, emptying either into Little Pigeon Creek or the Ohio River. In a few instances the streams have cut out wide depressions, and a heavier type of soil is usually found occurring along them. The type possesses good natural drainage. The streams which flow through it afford excellent outlets for all the drainage waters, and only in a very few instances has it been necessary to construct artificial drainage ditches. Occasionally, however, it has been found advisable to widen and deepen the streams, in order to increase their capacity for carrying off the surplus water during times of heavy rains or long wet periods.

In addition to the good natural drainage which this soil type possesses, it also has the power to retain moisture, the underlying silt or clay loam subsoil forming an excellent medium for storage of the soil water, so that with the aid of proper cultivation crops suffer but little from the effects of drought.

Over the more elevated portions of the type, and where the sand content of the soil is above the average, natural drainage is apt to be too thorough for most crops. In this case great care should be exercised in the methods of cultivating, particular attention being paid to the preservation of a surface mulch in order to carry the crops safely through the dry season of July and August. The lower lying portions of this soil type require artificial drainage to secure the best crops. Ditching and tiling greatly improve the productivity of such areas, and a large part of these is being artificially drained at the present time.

The Miami fine sandy loam is of alluvial and glacial origin. The underlying silt and clay loam is undoubtedly reworked loess material washed down from the uplands, while part of the sand which goes to make up the sandy loam was deposited at an early date during times of exceptionally high water. The sand underlying the Miami silt loam bordering this type on the east has been washed over the surface of this soil and has entered into its composition.

The type is well adapted to almost all kinds of crops that will grow in this latitude, with the possible exception of timothy, which requires more moisture than this soil can retain during the dry season. Ordinarily wheat averages 20 bushels per acre. The yield of corn on the cob varies from 40 to 80 bushels per acre, depending upon the manner in which it is cultivated, and of oats only from 25 to 30 bushels, owing to the lack of sufficient moisture fully to mature the crop. Early potatoes yield from 75 to 175 bushels, while the late varieties produce from 100 to 125 bushels per acre.

The Miami fine sandy loam is one of the best soils in the area for the production of tobacco. It produces usually from 700 to 1,000 pounds per acre, although a much higher yield is often obtained. Tobacco is considered a sure crop, and often does well when corn, wheat, and other crops are a failure.

Apples and peaches are grown to some extent, but the apples do not keep as well as those grown on heavier types. Small fruits are cultivated to a limited extent, the quantity produced being scarcely sufficient for home consumption. The soil is well adapted to truck crops, but its distance from good markets renders their production unprofitable at the present time.

The following table gives mechanical analyses of typical samples of this type of soil:

Mechanical analyses of Miami fine sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand 0.25, to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10790	2 miles E. of Hatfield.	Brown fine sandy loam, 0 to 14 inches.	0.0	1.7	10.0	28.6	19.2	32.1	8.3
10788	1 mile E. of Richland City.	Brown to gray fine sandy loam, 0 to 12 inches.	.2	1.7	6.4	27.1	18.6	34.9	11.1
10791	Subsoil of 10790..	Heavy fine sandy loam, 14 to 36 inches.	.1	1.2	7.7	26.1	10.7	39.7	14.2
10789	Subsoil of 10788..	Yellow loam, 12 to 36 inches..	.1	.8	3.0	17.3	14.2	40.3	24.4

WAVERLY SILT LOAM.

The Waverly silt loam covers a very limited part of the area surveyed, but agriculturally it is one of the most valuable soils. The soil has a depth of from 12 to 18 inches.. It is a silt loam, slightly plastic when wet, gradually becoming heavier as the depth increases, and varying in color from gray to dark brown, according to the amount of organic matter present.

The subsoil is a light-yellow silt loam, containing a larger percentage of clay than the soil, and becoming heavier at a depth of 25 or 30 inches. In places the subsoil is a mottled, heavy, drab silt loam of a much stiffer nature than the soil, but still retaining its silty character.

The greater part of this type, as it exists in the area, contains a comparatively small amount of organic matter, but in the poorly drained places, where there has been a continual accumulation of humus, the percentage of organic matter is very high.

The Waverly silt loam occurs as narrow strips bordering most of the small streams in all sections of the area, but seldom extends back more than a quarter of a mile from the streams. The largest area, which lies along the Cypress Creek ditch west of Boonville, has an average width of 1 mile. A second extensive area occurs at the head of the Willow Pond ditch, northwest of Rockport, where the soil contains a very large amount of organic matter and is of a much darker color than the greater proportion of the type. The Willow Pond area has only recently been drained and put under cultivation, and both soil and subsoil are of a slightly heavier nature than the typical Waverly silt loam.

In topography the type is level, with a gentle slope toward the small streams. It occupies the low depressions near the sources of streams and the narrow valleys between the rolling hills. The streams have usually cut their channels down several feet below the lands bordering them, but are generally insufficient to drain thoroughly the larger areas without artificial means. This soil is easily drained by straightening and deepening the small stream courses and cutting lateral ditches at frequent intervals through the wet areas. Tiles are used with excellent results, and at present the greater part of this soil is well drained. When ditched and tiled thoroughly it is very productive, and in several localities its value has been increased from $10 to $50 an acre by the installation of a good drainage system.

The Waverly silt loam is derived from material washed from the uplands at times of heavy rains and deposited in the depressions and shallow valleys, mixed with decaying vegetable matter. The remains of decomposed logs and other organic matter have been found in the soil at a depth of from 6 to 10 feet below the surface, indicating that the now shallow valleys have been gradually built up to this present level by the steady accumulation of material from the uplands.

Where the soil is well drained corn averages from 50 to 70 bushels; wheat, 20 bushels; oats, 40 bushels; clover and timothy, about 2 tons, and tobacco from 1,000 to 1,200 pounds per acre. Large yields of potatoes and other vegetables are obtained. The soil seems best adapted to corn and tobacco. The corn crop is never a failure, and when well cultivated larger yields than those above mentioned are obtained. Tobacco gives large yields per acre, and, as quantity rather than quality is what the growers strive for, much of this soil type is devoted to its production.

The following table gives the mechanical analyses of typical samples of the Waverly silt loam:

Mechanical analyses of Waverly silt loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10806	4 miles N. of Rockport.	Brown to yellow silty loam, 0 to 10 inches.	0.2	0.5	0.5	3.6	10.4	74.8	10.1
10804	2 miles E. of Boonville.	Yellow fine silty loam, 0 to 12 inches.	.2	.2	.1	.5	5.8	82.1	11.1
10805	Subsoil of 10804..	Yellow silty loam, 12 to 36 inches.	.3	.5	.3	.4	5.7	77.8	15.1
10807	Subsoil of 10806..	Yellow heavy silty loam, 10 to 36 inches.	.2	.5	.5	3.5	10.7	67.5	16.7

WAVERLY CLAY LOAM.

The soil of the Waverly clay loam consists of about 6 inches of heavy, light-brown to gray silt loam, often containing small iron concretions scattered over the surface and through the soil. The soil becomes heavier with depth and grades into a very heavy silt loam containing a large percentage of clay. At a depth of from 12 to 20 inches the subsoil is a sticky, mottled clay, usually containing small iron concretions. It becomes stiffer and more tenacious as the depth increases, making the soil difficult to drain. When plowed and exposed to the air the subsoil often becomes whitish in color and dries into hard crusts or clods very difficult to pulverize. There is apparently little organic matter in the soil, except in small swampy areas, and no attempt has been made to drain these areas or to put them under cultivation. In such places the soil is known locally as "glade" or "crawfish" land and is of little agricultural value.

The Waverly clay loam occupies small areas adjacent to many of the small streams, but in the north central part of the area there is one body of considerable extent. This occupies the low, flat country which extends along Little Pigeon Creek and other streams from near Tennyson to where Little Pigeon Creek leaves the area. There are a few ridges and shallow depressions in this area, but the greater part of the land is almost level. It is drained with great difficulty, on account of the compact nature of the soil, the level topography, and the slight elevation above the level of the streams.

Where this soil is ditched and tiled and a complete system of artificial drainage established, the least productive phases have been made to produce average crops. Where no system of drainage is practiced, these lands are either covered with a growth of scrub oak or are used exclusively for pasture.

A small area of the type situated about 2½ miles north of Rockport deserves special mention. It occupies an old terrace of the Ohio River, and has a more rolling topography than the typical areas. This, together with its elevation and nearness to the river, gives it better drainage and a higher crop value than this soil usually possesses. This area is of too small extent, and the soil occurring between the low ridges is too typical of the Waverly clay loam to classify it as a separate soil type.

The Waverly clay loam is derived from the same loess material as the Miami silt loam of the uplands, but its position in the low, flat valleys, only a few feet above the present level of the streams, has caused this material to undergo considerable change. The poor drainage, the addition of finer material washed down from the uplands, the effect of water which collects and spreads over the low areas in wet seasons, and the material deposited over these sections by former inundations, all combine to make this a much heavier soil than that formed from the loess on the well-drained uplands.

The yields of the various crops cultivated on this soil depend to a great extent on the thoroughness of the drainage and cultivation. With the methods usually practiced corn will average from 10 to 15 bushels and wheat from 10 to 12 bushels per acre. Wheat often gives larger yields in a favorable season if preceded by clover. Very little oats is grown on this type, and a yield of from 15 to 20 bushels per acre is estimated as an average crop.

Tobacco is grown quite extensively on this soil, a heavy, coarse-textured leaf being produced. This tobacco does not command so high a price as that grown on the more sandy soils, but the plants are larger and larger yields are obtained, the average being from 1,000 to 1,200 pounds per acre.

This soil seems best adapted to clover, timothy, and redtop, and a large amount of hay is harvested yearly from it. The hay crop averages from 2 to 3 tons per acre for each cutting, and the facilities for shipping this product to southern cities make it a profitable industry.

The Waverly clay loam varies considerably in agricultural value, according to its position, topography, and the methods used in its management. The greater part of it is considered a very poor soil for general farming purposes, but where it occupies the low ridges a few feet above the more level areas and is well drained very fair crop yields are usually obtained. Small areas frequently appear only a few rods apart where, on account of the local influences of topography and natural drainage, fair yields are produced on one field, while on the adjacent one, which is too wet and poorly drained, nothing except clover and grass can be successfully grown.

The following table gives mechanical analyses of this type:

Mechanical analyses of Waverly clay loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10786	1¼ miles NE. of Richland City.	Heavy silty loam, 0 to 6 inches.	0.3	1.0	1.4	3.5	8.9	56.3	28.6
10784	3¼ miles E. of Boonville.	Clay, 0 to 6 inches	.3	1.0	.7	1.0	1.8	60.0	35.1
10787	Subsoil of 10786.	Gray clay, 6 to 36 inches	.4	1.3	1.6	3.7	8.6	53.2	31.0
10785	Subsoil of 10784.	Yellow to gray heavy clay, 6 to 36 inches.	.2	.4	.3	.3	1.1	53.9	43.7

WAVERLY CLAY.

The Waverly clay is an alluvial soil found in the low bottom lands bordering the Ohio River. It extends uniformly over that section of the area which is subject to annual inundation during the spring floods.

The soil, to a depth of from 8 to 10 inches, consists of a light-brown clay loam, often containing a small amount of sand. The percentage of silt and clay is very large, and the soil rapidly becomes stiffer and more tenacious with depth, grading into a heavy tenacious clay subsoil of a brown or drab color, which is often mottled in the lower depressions. A few small iron concretions are frequently seen in the more swampy areas, both in the soil and subsoil.

This type of soil is overflowed annually, and when the water recedes the lands, on drying, become baked and sun cracked, making its cultivation difficult.

The Waverly clay occurs in a large area in the extreme southern part of Spencer County and embraces the greater part of the lands lying within the great bend of the Ohio River, southwest of Rockport. It also extends in narrow strips a short distance up the valleys of some of the small streams which flow through this section of the area. These lands are comparatively level, but are traversed by numerous narrow sloughs and shallow, swampy depressions with low ridges intervening.

The type as a whole occupies a basinlike depression, surrounded on three sides by the sand ridge which extends along the banks of the Ohio River and on the north by the rolling uplands. The small streams which flow through it have cut their channels several feet below the surface of the greater portion of the area, and as soon as the floods subside the water covering the lowlands finds its way back to the river through these outlets. Drainage is difficult over a large proportion of the type, but ditching and tiling greatly increase its agricultural value.

The material from which this soil is formed is brought down by the Ohio River at times of high water and is deposited over the areas flooded. During the annual spring floods the river water backs up through the openings which the small streams have cut in the sandy ridge and spreads out over the low flat country of the interior. The fine particles of silt and clay held in suspension are gradually deposited over the bottom lands, while the sand and coarser particles are deposited nearer the main current of the stream. This annual addition of new material to the soil tends to maintain its productiveness, and when the crops are not damaged by overflow large yields are obtained. Along some of the narrow depressions, where the current of the stream is strongest during the overflow, the surface soil has been eroded and the stiff clay subsoil exposed. Crops planted in such places are either a total failure or give very low yields.

The Waverly clay is cultivated almost exclusively to corn, which averages about 40 bushels per acre. During favorable seasons and where the land is well drained and cultivated as much as 60 bushels is often produced. Wheat yields from 18 to 20 bushels per acre, although the crop is sometimes destroyed or greatly damaged by the floods. It is estimated that about one wheat crop in three is harvested from this soil. Wheat is often sown in the fall, and if the crop is destroyed by the overflow it is followed by corn planted in the late spring. Oats are grown to a very small extent, as they suffer from the same disadvantages as wheat; but when not damaged by floods 40 bushels per acre may be produced. Tobacco is grown to a limited extent, and about the same grade of the dark export type is obtained as that grown on the Waverly clay loam. The yield is about 1,000 pounds per acre. Clover, timothy, and other grasses give yields of from 2 to 3 tons per acre.

This type, however, is best adapted to the production of corn. The soil is usually in condition to cultivate by the latter part of April, and often at an earlier date, and as the corn crop is planted in May it is very seldom damaged by overflow, and large and profitable yields are thus almost always assured.

The following table gives mechanical analyses of typical samples of the Waverly clay:

Mechanical analyses of Waverly clay.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10808	7½ miles SW. of Rockport.	Heavy clay loam, 0 to 8 inches.	0.3	1.1	0.7	1.8	3.0	58.2	34.8
10810	7½ miles SW. of Rockport.	Brown heavy clay loam, 0 to 10 inches.	.1	.2	.3	1.1	1.5	55.5	41.2
10809	Subsoil of 10808	Stiff clay, 8 to 36 inches	.7	2.2	1.2	2.9	4.7	51.6	36.6
10811	Subsoil of 10810	Brown to gray heavy clay, 10 to 36 inches.	.1	.3	.5	1.5	1.8	46.8	49.0

WAVERLY FINE SANDY LOAM.

The Waverly fine sandy loam is a type of minor importance in the area on account of its limited extent. It is well adapted to a variety of crops, and, owing to its elevation above the flood plain, the crops are seldom seriously injured by the overflows of the Ohio River.

The soil to a depth of 15 inches is a light-brown to gray fine sandy loam, the sand content being usually large and of the finer grades. As the depth increases the soil becomes heavier, and at from 15 to 20 inches passes into a brown fine sandy loam, containing a larger percentage of clay. The sand content, depth of soil, and size of the sand particles often vary according to location. That portion of the type lying nearest the river is of a coarser texture and is often deeper than that immediately bordering the Waverly clay.

The Waverly fine sandy loam occupies a narrow ridge extending along the whole course of the Ohio River, where it forms the southern boundary of the area, except where the Rockport hills reach to the water's edge. This ridge slopes gently toward the low inland basin occupied by the Waverly clay, but its slope toward the river is more abrupt and ends in the steep banks which extend to the water's edge. Its elevation above the river and the neighboring lowlands, together with the sandy nature of the soil itself, gives to this type excellent drainage. Ditching and tiling are never necessary, as only a very small proportion of the type is subject to overflow.

This sandy ridge was formed before the river had cut its channel down to its present level. During times of overflow the water, spreading over the more level sections, deposited the coarser material near the banks of the river. The coarser sands were deposited near the main current, while the finer grades were carried farther inland and laid down near the deposits of silt and clay. As the river gradually deepened its channel, and as more material was annually deposited along its banks, a natural levee was soon formed, consisting of a sand ridge several feet above the flood plain of the river. Small quantities of silt, clay, and organic matter, becoming mixed with the sand, formed a soil which is not only productive, but easily cultivated.

During a very dry season the crop yields are small, but with an average amount of rainfall large yields of oats, corn, wheat, potatoes, melons, and navy beans are secured. Corn averages from 40 to 50 bushels, wheat from 15 to 20 bushels, and oats from 25 to 30 bushels per acre. Tobacco is also grown on this soil and averages about 700 pounds per acre. The yield is not so large as that obtained on the heavier soils, but the leaf grown usually brings a higher price. All vegetables do well on this soil. A large acreage is devoted to navy beans. It is also excellently adapted to alfalfa, while a large yield of clover is always obtained. The type is best adapted to corn, melons, alfalfa, and early vegetables, the latter being grown for local markets.

The following table gives mechanical analyses of typical samples of the Waverly fine sandy loam:

Mechanical analyses of Waverly fine sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10802	3 miles S. of Rockport.	Brown fine sandy loam, 0 to 12 inches.	0.1	0.4	0.6	23.1	34.7	31.0	9.9
10800	6 miles S. of Rockport.	Gray to brown heavy fine sandy loam, 0 to 15 inches.	.1	.3	.3	9.7	37.6	38.9	13.1
10803	Subsoil of 10802..	Heavy fine sandy loam, 12 to 36 inches.	.1	.1	.4	18.0	32.8	32.4	16.0
10801	Subsoil of 10800..	Brown loam, 15 to 36 inches..	.1	.2	.2	8.0	32.9	41.2	17.5

AGRICULTURAL METHODS.

To obtain the best results on the soils of the area very careful methods of cultivation are necessary.

When the Miami silt loam is constantly kept in the loose condition required for the successful cultivation of corn, the upper soil soon becomes eroded and its productivity is greatly lessened. The underlying subsoil becomes exposed on the surface and the land often fails to give sufficient yields to make its cultivation profitable. The usual method employed to restore these lands to their former state of productiveness is to seed them down to clover. A fair stand of clover is usually obtained, except on a few small areas where erosion has been greatest. The lands are heavily fertilized with stable manure or commercial fertilizer and the fields are pastured to sheep or other live stock. By this method much of the worn-out land in the area has been reclaimed and profitably cultivated to all crops adapted to the soil.

Where a rotation of crops is practiced the upland soils suffer very little from erosion and profitable yields are continuously obtained without the aid of commercial fertilizers. Some system of crop rotation is in use in all sections of the area and on all the soil types, with the exception of the Waverly clay, but crop rotation is of the greatest importance on the Miami silt loam and the Miami fine sandy loam. The soils occupying the river flats and low upland valleys are not so easily eroded, and are annually enriched by the addition of new material washed down from the surrounding uplands or deposited by water.

Drainage is the most important factor in the management of the soils occupying the lower and more level sections of the area. The agricultural value of a large proportion of the Waverly silt loam and of the Miami fine sandy loam has been greatly increased where a good system of artificial drainage has been established. The Waverly clay loam, on account of its level topography and slight elevation above the level of the streams, is the most difficult soil of the area to drain, but where ditching and tiling are practicable good results are always obtained. Where tile drainage is used the tiles are laid at a depth of 2½ to 3 feet and are placed 30 or 35 yards apart. These open into the main drainage ditch, which leads to the neighboring stream. This system is adequate to drain the greater part of the upland valleys and low depressions occupied by the Waverly silt loam and the Waverly clay loam, but the topography of some of the small swampy areas occupied by the latter makes thorough drainage almost impossible.

When preparing the soil for the cultivation of wheat the field is plowed about the 1st of August. It is then dragged, harrowed, and rolled three or four times. The wheat is usually drilled in during the first week in September and is harvested early in July. The preparation of the land for oats is about the same as for wheat, except that the land is seldom worked more than twice before the crop is drilled in. Oats are sown during March and April, and the crop is harvested during the latter part of July.

For corn the soil is plowed in the early part of April or as soon as the season permits. It is then dragged or harrowed until it is in a loose and thoroughly cultivated condition. The crop is planted from the 10th to the 20th of May, and should be cultivated once each week until it becomes too large.

Tobacco seeds are first sown in beds located on the sunny hillsides, which afford them a natural protection. The tobacco beds are covered with a thin canvas or cheesecloth. The plants are set out during the latter part of June and the crop matures in September. It is then cut and hung on low scaffolds in the fields until the leaves begin to turn yellow. Great care is taken to protect it during rainy weather while in the field. After a short interval of time it is removed to open, well-ventilated barns, stripped from the stalks, and suspended from scaffolds. It is alternately dried and softened, as the climatic conditions vary from dry to damp, and when thoroughly cured is assorted and put on the market. No curing by means of artificial heat in especially constructed barns is practiced at present in the area.

AGRICULTURAL CONDITIONS.

The agricultural interests of the area are centered in the production of corn, wheat, and tobacco. A limited acreage is devoted to the production of oats, hay, and vegetables, but the climatic conditions, soils, and facilities for marketing all tend to make the area particularly well adapted to the three staples first named. The farmers of the area are intelligent and energetic, and the majority of them are prosperous and free from debt. Large yields of all crops grown, together with the prevailing good prices, have placed the farmers in all sections of the area in excellent financial condition. Great interest is manifested in farmers' institutes, agricultural societies, and all kinds of local organizations which tend to advance the interests of the rural population.

The average farm dwelling consists of a neatly painted two-story frame building, while the barns and other outbuildings are modern and well kept. These are always large enough to store the crops, to shelter the small number of stock which each farmer invariably owns, and to protect the farm machinery during the winter months.

About three-fourths of the farmers own the lands they cultivate, the remainder being tenants on the farms of the larger landholders. Lands are usually rented on a share basis, but a few tenants in the upland sections pay cash. When rented on shares the landowner receives from one-fourth to one-third of the crop produced. The tenant furnishes the seed, work animals, farm machinery, fertilizers, and labor, receiving from two-thirds to three-fourths of the crop made. From $3 to $4 an acre is the usual cash rent for farms in the Miami silt loam or Miami fine sandy loam, but a higher rate is obtained for well-drained lands in the Waverly silt loam. The Waverly clay loam and Waverly clay types of soil are never rented for cash, the uncertainty of a profitable yield, on account of the liability of crops on these areas to damage or destruction by floods, droughts, or unfavorable seasons causing the share system to be preferred by the tenant.

The largest farms in the area are situated along the Ohio River on the low, flat areas of Waverly clay. They average from 150 to 300 acres each, and, owing to the annual flooding of this section during the early spring months, they are cultivated almost exclusively to corn. There are comparatively few dwellings or farm buildings in this part of the area, as the farmers cultivating these lands live on the neighboring uplands or on the sandy ridge bordering the river. On the Miami silt loam of the uplands and on the Miami fine sandy loam the farms have an average size of from 100 to 125 acres, and a very large proportion of the land is under cultivation. No large tracts are being cultivated on the Waverly clay loam.

Although some farmers own from 150 to 200 acres of this type, much of it is either used for pasturage or is covered with a growth of hardwood timber.

The average tenant in the area farms from 40 to 75 acres. As a general rule farm labor is plentiful throughout the year, the supply often exceeding the demand, so that many of the farm laborers are compelled at certain seasons to seek employment in the towns or neighboring counties. During harvest there is always a demand for experienced farm hands at good prices, and it is often difficult to obtain them at this season. The labor employed in the area is of a very efficient character. When hired by the month, from $14 to $20, including board, is paid for farm hands, but during harvest from 75 cents to $1 a day is the usual rate.

Corn, wheat, and tobacco are the principal products, each being grown on every variety of soil found in the area. A failure of the corn crop on many of the soil types is very rare, and during a favorable season an excellent crop is always obtained. This crop can not be grown continuously on the rolling uplands without involving damage to the soil from erosion. As the soil becomes loose and friable when frequently cultivated, much of it is washed from the surface of the rolling hills to the neighboring valleys. However, when a rotation of crops is practiced large yields are continuously obtained and the general productiveness of the soil remains unchanged.

A number of varieties of wheat are grown in the area, the most important being the Pool, the Red Wonder, the Russian Red, and the New Columbia. The Pool is the variety most widely grown, but the Red Wonder seems better adapted to the more sandy soils.

The greater part of the tobacco produced in the area is of the dark export type, but on some of the lighter soils a small amount of Burley is grown. The Pryor and One-sucker are the varieties of dark tobacco most widely cultivated, and a vigorous growth of these is always obtained on the heavier soils. The leaf is heavy and oily, varying in color from a light brown to a dark reddish brown. While a comparatively small quantity of Burley tobacco has been grown in the area, the present good prices are causing the production of this variety to increase rapidly. When the difference in the market prices is not very great the farmers prefer to grow the dark export type, as larger yields per acre are produced and it requires much less attention, both while the crop is in the field and while it is being cured. Only a small part of the tobacco grown in the area is consumed in the United States, the greater proportion being exported to foreign markets, where the dark, heavy types of this product are in greater demand.

In connection with the foregoing discussion of the agricultural products of the area it seems advisable to point out again the relation between these products and the several soils. The Waverly clay and the Waverly fine sandy loam are well adapted to corn. The Waverly silt loam is also excellently adapted to this crop, and when well drained it produces larger yields than any other type in the area. The Miami silt loam is best adapted to wheat. Large yields of wheat are also harvested annually from the Miami fine sandy loam, and while there is no great difference between these types in the yield per acre, that produced on the silt loam of the uplands is of a higher grade and, as a rule, commands better prices on the markets. Large yields of wheat are obtained on the Waverly clay when the crop is not destroyed by floods. The Waverly clay loam, when properly drained, is well adapted to the production of the dark-leaf tobacco, and yields of from 1,000 to 1,200 pounds per acre are realized. This soil, however, is best adapted to clover and timothy, a large part of the hay produced in the area being grown on it.

The Waverly fine sandy loam and the Miami fine sandy loam are well adapted to melons, and the heavier, poorly drained phases of these types produce large yields of oats. Burley tobacco is also grown on these sandy loams, and with proper care in its cultivation, cutting, and curing a very fair grade is often obtained. Tomatoes, small fruits, and early vegetables are well suited to these sandy soils, and limited experiments have demonstrated that alfalfa does well, especially on the Waverly fine sandy loam which borders the Ohio River.

The transportation facilities of the area are excellent. Two branches of the Southern Railroad traverse the area, one of which terminates at Rockport, an important local shipping point on the Ohio River. The facilities afforded by both the river and the railroads cause Rockport to receive a large amount of produce from the surrounding country on the way to more distant markets.

A large number of well-kept county roads connect Boonville, Rockport, Chrisney, and other smaller towns with all sections of the surrounding country. The streams are all well bridged, and the more important county roads are macadamized for some miles out from the leading towns.

Several landings are situated at short intervals along the Ohio River, where the products of the neighboring farms are loaded on the small river steamers and transported direct to Louisville, Owensboro, or other large markets. An electric car line is now being constructed to connect some of the smaller towns with Evansville, Rockport, and other important local markets. This will greatly facilitate traffic, and will enable the farmers in certain sections of the area to market their produce with more dispatch and at much less expense than at present.

Owensboro, Ky., is the market for almost the entire corn crop of the area. The large distilleries located there create a constant demand for this product. The greater part of the wheat and tobacco is shipped to Louisville, Ky. A small portion of the tobacco crop is marketed at Owensboro, and a still smaller proportion is shipped direct from the area to foreign markets. Very few farmers own more than a few head of stock. No cattle are raised for other than the local markets, but a large number of hogs are raised and marketed at Louisville and Cincinnati. A few farmers in the area have made a specialty of this industry, and as good prices are obtained it has proved very profitable.

The diversity of crops grown, the natural productiveness of the land, the transportation facilities afforded by the river and the railroads, and the nearness to large markets all tend to make the area surveyed one of the most prosperous sections of the State.

SOIL SURVEY OF THE SUPERIOR AREA, WISCONSIN-MINNESOTA.

By **THOMAS A. CAINE** and **W. S. LYMAN.**

LOCATION AND BOUNDARIES OF THE AREA.

The area is located at the head of navigation on the Great Lakes, and includes parts of Wisconsin and Minnesota. It is bounded by meridians 91° 48′ and 92° 10′ 30″ longitude west from Greenwich, and by parallels 46° 19′ 35″ and 46° 50′ north latitude. It includes ranges 12 to 14 and townships 45 to 50. Deducting the portion of the area occupied by Lake Superior and St. Louis Bay, there are 308,800 acres, or about 482 square miles in the survey.

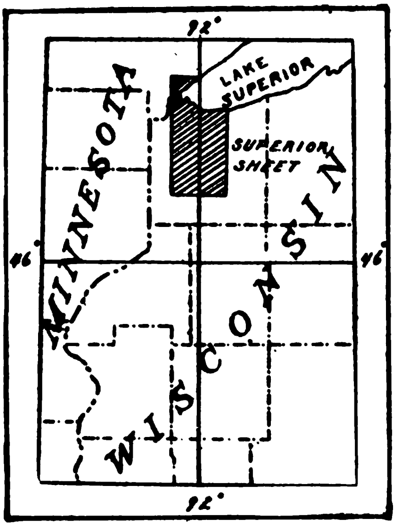

FIG. 31.—Sketch map showing location of the Superior area, Wisconsin-Minnesota.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Douglas County, in which almost the entire area surveyed lies, was organized in 1854, being detached from La Porte County. The population of the county was small until the era of railway building began in 1885, and the cities of Duluth and Superior grew rapidly, owing to the building of docks and railroad terminals. In 1885 and 1886 a great many settlers came in and took up homesteads, but many left as soon as they had acquired legal possession of the land and had removed the pine. Those who remained formed a nucleus for agricultural development. During the past ten years the farming population has increased sixfold, and a steady increase continues.

About two-thirds of the farming population of the area is composed of Scandinavians, most of whom are foreign born. About 5 per cent of the population is from Finland, and the remainder is about equally divided between immigrants from Canada and from Iowa, Illinois, and Indiana.

Only about 1 per cent of the land in the area is under cultivation, but probably as much as 5 per cent is being prepared for cultivation, and the area cropped is constantly increasing. Farm operations have now advanced beyond the experimental stage, and permanent farm buildings are being erected throughout the area.

CLIMATE.

The winters are long and severe; the springs are short—in fact, almost wanting; the summers are short, but warm, with cool nights; and the falls are long, cool, and pleasant. The presence of so large a body of water as Lake Superior has a marked influence upon the climatic conditions of the region adjoining. Through its influence the delightful autumns are prolonged until late in November, and severe weather continues until late in March.

In the lake basin the average date for the last killing frost in spring is about May 15, while that of the first in fall is about September 1, so that the length of the growing season is about three and one-half months. In the sandy region in the southern part of the area the average date of the last killing frost in spring and the first in fall is about ten days earlier than in the lake basin. This difference is believed to be due not alone to the influence of the lake, but in some degree to the difference in the soils. The cool lake tends to retard the springs, and the stiff, tenacious red clay adjoining does not dry out and warm up readily. The cool lake winds in the spring are tempered before reaching the southern part of the area, and the sandy soils dry out and warm up more readily than the clay of the lake basin. In the fall, however, the conditions are reversed. The sandy soils in the southern part of the area lose the heat absorbed during the summer more rapidly than does the clay of the lake basin, while the lake water, warmed somewhat during the summer, tempers the air and aids in prolonging the growing seasons of the region immediately adjoining.

The climatic conditions of the growing season may be judged to some extent by the fact that field corn can not be produced, and tomatoes do not mature, as a rule, unless transplanted from a hotbed. It has been observed by the old settlers that as the clearings progress the conditions become more favorable for long-season and all other crops, the soils becoming dryer, as well as warmer, and better adapted to growing crops. Some of the old settlers are even hopeful enough to believe that in time a hardy variety of field corn can be successfully grown.

The annual precipitation is usually sufficient and well distributed throughout the growing seasons. The climate of the region, though cool, with long, severe winters, is bracing and healthful. The following table shows the normal monthly and annual temperature and precipitation throughout the year, as compiled from records of the Weather Bureau stations at Duluth, Minn., and Hayward, Wis.:

Normal monthly and annual temperature and precipitation.

Month.	Duluth, Minn.		Hayward, Wis.		Month.	Duluth, Minn.		Hayward, Wis.	
	Temperature.	Precipitation.	Temperature.	Precipitation.		Temperature.	Precipitation.	Temperature.	Precipitation.
	° F.	*Inches.*	*° F.*	*Inches.*		*° F.*	*Inches.*	*° F.*	*Inches.*
January	10.4	1.07	9.6	1.36	August	64.7	3.34	66.5	3.57
February	14.5	1.11	12.0	1.01	September	56.2	3.86	56.8	3.73
March	24.0	1.66	23.0	1.90	October	44.9	2.59	46.1	3.28
April	37.9	2.42	42.0	2.50	November	29.4	1.61	26.7	1.35
May	48.0	3.40	54.0	3.70	December	17.8	1.36	15.8	1.12
June	57.8	4.59	63.2	4.40	Year	39.3	30.73	40.4	31.68
July	65.9	3.72	69.4	3.76					

PHYSIOGRAPHY AND GEOLOGY.

There are three distinct topographic divisions in the area. Beginning at the lake, the first is a plain, the boundaries of which are indicated on the soil map by the boundaries of the soil type Miami sandy loam. This plain is made up of lacustrine deposits of silt and clay that were laid down at the close of the Glacial period, at which time the waters of the Superior Lake basin stood at a considerably higher level than at present. The city of Superior is built upon this plain. Bordering the lake and St. Louis Bay there are cliffs of clay averaging about 25 feet in height, and from there the country extends southward with a gradual rise of about 30 feet to the mile for a distance varying from 5 to 15 miles, where the plain terminates rather abruptly with a range of hills.

The plain is crossed by a number of streams flowing directly north or northwest into the lake or the Nemadji River. These usually flow in narrow channels, which in places have been cut to a depth of 100 feet or more. The interstream areas are broad and flat.

The greater portion of the plain is underlain at considerable depths by the Potsdam sandstone of Cambrian age, but these rocks nowhere enter into the composition of the overlying clay and can only be seen in the bottoms of deep stream courses in the southern part of the plain. Farther to the south, however, where these clay deposits thin out along the ranges of hills, the underlying basic lava flows of the lower Keweenawan formation appear and impart to the clay of the plain a somewhat loamy texture.

The second topographic division of the area begins with the basic lava flows just mentioned. On the Wisconsin side these lava flows constitute a wide belt of country to the southward, but on account of their general concealment by the drift only that portion of them which appears on the surface and enters into the soil formation need be considered. A ridge, known as the Douglas Range, with an average width of about one-half mile, crosses the area in a west-southwesterly direction from the vicinity of Poplar to Black River Falls, and in many places the rocks appear as a distinct escarpment. The soil on top of the ridge and for some distance southward is partly residual. On the Minnesota side, in the vicinity of Duluth and along the north shore of the lake, the base of the lower Keweenawan formation appears and forms a continuous escarpment rising in places as high as 600 feet in a distance of 1 mile back from the lake. The soil on the escarpment and for some distance back is also partly a residual soil derived from the weathering of the rocks below. The red clay of the valley is found in places upon this escarpment, but it has been largely removed by erosion, and where found it is usually intimately mixed with fragments of rocks from the underlying formation and with gravel from the glacial deltas above.

The third topographic division of the area includes a rolling country in which prominent elevations are uncommon and in which the surface is so level in places that considerable swamp areas and a number of small lakes exist. It is composed largely of a blanket of glacial till, and the underlying lava flows of the lower Keweenawan formation seldom come to the surface, although fragments of the rock are more or less intimately mixed with the glacial material.

In the southeastern corner of the area there are a few sections of land which belong properly to another topographic division. It is a portion of the sandy plateau of the State known as "the Barrens." It is in this vicinity that the waters flow partly toward the Mississippi River and partly into Lake Superior.

The altitude of the area ranges from 602 feet, the present level of Lake Superior, to about 1,400 feet at a point within the city limits of Duluth. In the southern part of the area, along the divide which separates the waters of the Mississippi from those of the St. Lawrence, the elevation above sea level is about 1,200 feet.

SOILS.

The soils have been classified into eight types, but only five of these are agricultural soils. The others, Rock outcrop, Rough stony land, and Dunesand, are of relatively small extent. Muck occupies a comparatively large area, viz, 47,808 acres, or over 15 per cent of the territory covered by the survey. Under present conditions this may also be classed with the unproductive soils. None of it is under cultivation, and probably will not be for some time to come, as it will require considerable expenditure to reclaim it, and land of the more easily reclaimed types is very cheap.

The following table gives the names and areas of the several soils:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Superior clay	122,880	39.8	Rock outcrop	5,632	1.8
Miami sandy loam	105,536	34.2	Miami sand	4,608	1.5
Muck	47,808	15.3	Dunesand	1,536	.5
Superior sandy loam	14,208	4.6	Total	308,800	
Rough stony land	6,592	2.1			

SUPERIOR CLAY.

The Superior clay is a heavy red clay with apparently no difference in color or texture between the soil and subsoil, being close, compact, and almost impervious either to air or water. When wet it is of a bright, brick-red color, and quite adhesive and gummy, sticking to wagon wheels in great lumps. When dry, cracks an inch or more in width are common on the surface and the soil breaks up into cubical blocks. Occasionally there are small fragments of rock in both soil and subsoil, and usually upon new ground there is an inch or so of vegetable mold.

This is the most extensive soil type in the area, occupying an extensive plain reaching from the lake edge inland for a maximum distance of 15 miles. Along the lake it occurs as cliffs of clay with an average height of about 25 feet, and the surface rises gradually inland at the rate of about 30 feet to the mile, and is terminated rather abruptly with a range of hills. The surface is traversed by a number of streams flowing in deep, narrow channels, as described in the chapter on physiography and geology. The interstream areas are broad and flat.

With the inclination of the surface toward the lake, and with the number of deep, narrow water courses intersecting it and leading direct to the lake, the opportunity for drainage is good. The type is exceedingly retentive of moisture, and owing to its almost impervious nature it is greatly improved by open drains. Underdrainage is not thought practicable, as in order to escape damage by frost the tiles would have to be laid too deep to be efficient in a soil of the impervious nature of this type. The crops are much benefited when the fields are plowed in narrow lands in the direction of the slope.

The Superior clay is lacustrine in origin, having been deposited in the lake bottom at the close of the glacial period, at which time the basins of lakes Superior and Michigan stood at a considerably higher level than at present. The inflowing glacial streams carried gravel, sands, silt, and clay; the coarser materials—sand and gravel—fell near shore, while the finer silt and clay particles were carried in suspension by the water and spread over the lake bottom farther from shore. Later the lake level lowered between 400 and 500 feet and exposed these fine sediments. As the color would indicate, the material contains a considerable proportion of iron, due doubtless to the fact that there is so much iron in the near-by ranges to the northward, from which the material was probably largely derived.

This type of soil is unusually well adapted to timothy and clover, and as yet these are the leading crops, mainly for the reason that with the present demand and high prices for hay in the Duluth and Superior markets and in the near-by logging camps nothing else pays so well. The clover grows waist high, and is usually grown with timothy, which also makes a luxuriant growth. A few fields of wheat were seen, and the average yield is about 15 bushels per acre. The soil is too cold and the season too short for corn to mature. It can be grown successfully for fodder, however, and sweet corn does fairly well.

The yields of all crops on newly broken areas of this soil are often unsatisfactory, but the second crop is always better, and the soil shows more improvement with use and more lasting effects of manuring than any other type in the area. All yields are greatly increased by the incorporation of coarse manure, the beneficial effects of which seem to be due not so much to the addition of plant food as to the change which is brought about in the texture of the soil. Good crops of potatoes, rutabagas, pease, beets, and, in fact, all root crops, are grown in the gardens upon this type.

The following table gives the results of mechanical analyses of typical samples of this type:

Mechanical analyses of Superior clay.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11941	Poplar	Red tenacious clay, 0 to 10 inches.	0.3	1.8	2.0	6.4	7.3	38.8	43.4
11943	3 miles W. of Coyne.	Red stiff clay, 0 to 10 inches.	.8	5.4	4.0	6.4	5.1	30.5	48.0
11939	Superior	Red tenacious clay, 0 to 10 inches.	.2	1.1	1.5	5.4	5.3	28.6	58.2
11942	Subsoil of 11941	Red tenacious clay, 10 to 36 inches.	.1	1.5	2.9	8.0	5.4	36.9	45.2
11940	Subsoil of 11939	Red tenacious clay, 10 to 36 inches.	.4	1.2	1.2	5.6	4.7	30.7	56.0
11944	Subsoil of 11943	Red tenacious clay, 10 to 36 inches.	.1	.7	.8	2.5	2.0	34.5	59.3

MIAMI SANDY LOAM.

The Miami sandy loam, to an average depth of 10 inches, consists of a grayish to brownish sandy loam containing considerable silt, underlain to about 30 inches by a medium-textured, incoherent red sandy loam. Below 30 inches the subsoil becomes somewhat heavier in texture and retains moisture better than that immediately above. The surface soil varies considerably in texture within short distances, being loamy in depressed and level areas, and rather sandy and gravelly upon the small knolls. The knolls, however, are not extensive enough to be mapped upon a scale of 1 inch to the mile. Sometimes rocks varying from 4 inches to 4 feet in diameter are strewn upon the surface and disseminated through the soil and subsoil in such quantities as to interfere seriously with cultivation and to add greatly to the cost of clearing.

The Miami sandy loam is confined to the southern part of the area, and lies wholly outside of the Superior lake basin. The surface is more or less rolling, with many kettle-hole depressions, shallow lakes, bogs, and peat marshes. These irregularities of surface, however, are not great enough to interfere with cultivation. The rolling character of the surface, together with the porous nature of the subsoil, insures good drainage, except in the above-mentioned marshy depressions.

This soil type is of glacial origin, being composed of a heterogeneous mass of silt, sand, gravel, and rocks transported from the north and more or less intimately mixed with the fragments of local trap rocks. The more loamy character of the soil in the depressions is the result of wash of the finer material from higher ground, and a relatively greater quantity of organic matter. Where the soil is unusually stony the underlying trap rock comes close to the surface, and has been incorporated with the glacial material. The watershed between the Mississippi and St. Lawrence systems occurs along the southern boundary of this type, where the bogs, marshes, and shallow lakes increase in size and number.

Very little of the Miami sandy loam is under cultivation, the largest areas being in the vicinity of Chaffey and Hawthorne. It is locally known as "hardwood" land, and is recognized as a safe soil for potatoes and all root crops. It is very well adapted to raspberries, blackberries, gooseberries, currants, and strawberries; and the fact that it is a warm soil and removed from the direct influence of the cold spring winds from the lake makes it especially desirable for those products. With proper care and attention potatoes yield as much as 150 bushels per acre. It is a fair type for pasture and meadow. Some oats are grown, but are fed in the sheaf. On account of the character and number of stumps and stones it is more difficult and expensive to clear than the Miami sand, but owing to its superior water-holding capacity it is more desirable than the latter type for trucking purposes. This type should be used for root crops and small fruit to supply the near-by markets, and enough stock should be kept upon the farms to consume the hay and straw, thereby keeping up the productivity of the soil through the manure thus produced.

The following table gives the results of mechanical analyses of both soil and subsoil of this type:

Mechanical analyses of Miami sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11927	4 miles SW. of Solon Springs.	Gray sandy loam, 0 to 10 inches.	1.9	13.7	21.8	35.5	9.4	15.0	2.7
11929	2½ miles E. of Hawthorne.	Sandy loam, 0 to 10 inches.	2.3	12.3	13.8	29.9	14.7	21.2	5.8
11928	Subsoil of 11927	Red sandy loam, 10 to 36 inches.	2.9	13.1	15.8	37.3	13.7	12.8	4.4
11930	Subsoil of 11929	Red sandy loam, 10 to 36 inches.	3.4	12.3	13.5	29.8	14.8	19.4	6.7

SUPERIOR SANDY LOAM.

The soil of the Superior sandy loam is a gray to reddish sand or light sandy loam of medium texture, varying in depth from 12 to 24 inches. In places the surface is strewn with small rocks and bowlders in such quantities as to interfere with cultivation. The subsoil is a stiff, tenacious, impervious red clay similar to the material forming the Superior clay. Sometimes the subsoil is interstratified with thin layers of fine sand.

The principal area of this type of soil is found bordering the southern edge of the Superior clay area, from the eastern limit of the survey more than half way across the area. It lies south of the Douglas Range and occurs as a strip varying in width from one-half mile to 3 miles. There are also four smaller bodies of this soil type lying within the Superior clay area. The surface is usually quite level and in places gently rolling, with sufficient rise to the southward to insure good natural drainage.

This part of the area lay along the shore of the lake, when it stood at a higher level, and was covered by comparatively shallow water. The red clay subsoil represents deposits upon the bottom of the lake in comparatively quiet times, while the thin layers of interstratified fine sand represent periods of disturbance, and the stony portions represent the places where the underlying trap rock comes close to the surface. The sandy soil is the result of wash from the higher lying sandy region to the southward. Within the territory occupied by this type there are some limited flat areas of medium to coarse sand entirely free from rocks and underlain by red clay at the usual depth, as if the sand had washed from higher ground before the lake level receded and had been subjected to the assorting action of waves or shore currents. There are also some small knolls of fine sand, under which the red clay subsoil lies deeper than usual. These knolls are too small to be shown on the map, and probably represent wind-blown material.

The Superior sandy loam is well adapted to all crops grown in the region. It has all the advantages of the Superior clay without possessing its disagreeable features. Like the Miami sandy loam, it is a warm soil and easily tilled, but it is more desirable than the latter, in that it is not so leachy and the effects of fertilizers are more lasting. Clover and timothy do nearly as well as on the Superior clay, and the pastures are excellent. Potatoes will yield from 100 to 200 bushels per acre, and the quality is better than that of those grown on the Superior clay. All of the root crops do as well as on the Miami sandy loam. The type is very well adapted to strawberries, raspberries, gooseberries, and currants. As to its possibilities for wheat, oats, rye, and barley nothing can be definitely said, because as yet not much of the land has been cleared and these crops have been grown only in small patches.

Owing to the dense forests of pine which formerly grew on this type it is the most expensive in the area to clear, but altogether it is the most desirable type for general farming in the area.

The following table gives the results of mechanical analyses of the soil and subsoil of the Superior sandy loam:

Mechanical analyses of Superior sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11937	3 miles SE. of Coyne.	Sand, 0 to 24 inches	2.0	10.6	12.7	42.0	20.0	7.9	4.9
11935	¼ mile N. of Poplar	Sandy loam, 0 to 16 inches.	3.5	14.1	13.8	31.9	17.4	13.6	5.4
11933	1¼ miles NW. of Rockmont.	Brown sandy loam, 0 to 18 inches.	4.0	14.3	12.8	29.4	14.2	15.7	9.2
11936	Subsoil of 11935	Red clay, 16 to 36 inches	.2	2.0	2.2	5.7	11.0	53.1	25.5
11934	Subsoil of 11933	Red sandy clay, 18 to 36 inches.	1.0	7.5	8.9	24.3	13.6	17.1	27.6
11938	Subsoil of 11937	Red tenacious clay, 24 to 36 inches.	.9	4.9	5.3	15.4	10.5	21.8	41.0

MIAMI SAND.

The Miami sand is an incoherent, loose, grayish to reddish sand of medium texture, with an average depth of about 8 inches, underlain to great depths by loose, incoherent, yellowish to reddish sand of the same texture. The soil has a tendency to drift when exposed to the wind. The sand particles are largely quartz, and disseminated through both soil and subsoil are a few rounded pebbles of various kinds of rock, ranging in size from one-tenth of an inch to 1 inch in diameter. Occasionally a glacial bowlder is seen.

The Miami sand occupies a single area covering several sections in the southeastern corner of the area, in the vicinity of Lake St. Croix, and is representative of a belt of country to the southward, 10 to 20 miles wide, and extending from Polk County through Douglas County to the Bayfield peninsula. The belt is known as the "St. Croix Barrens."

The surface of the type as a whole is an undulating plain sloping toward the southwest, over which are scattered a great number of small lakes, ponds, kettle holes, and springs. In the vicinity of Solon Springs the surface slopes rapidly toward Lake St. Croix, and this, together with the number of deep, narrow valleys cut by the inflowing streams, makes this part of the type rather hilly and rough. The soil, too, is a little more stony in this place. Immediately adjoining the lake is a narrow area which is still more stony, due, doubtless, to the fact that in earlier times this was the bed of a glacial river.

Owing to the loose, open texture of the type, its power to retain water is low, and in many places the crops, except in wet seasons, are apt to suffer from drought. Successful farm operations so far have been confined either to very level uplands or to the depressions along streams.

The Miami sand owes its origin to the assorting action of flowing water as it issued from the melting ice at the close of the glacial period.

The soil responds readily to a dressing of barnyard manure, but the effects are not so lasting as upon the closer-textured Miami sandy loam lying to the northward. In localities where the moisture conditions are favorable and where a liberal application of manure is used the soil is especially adapted to potatoes, and judging from the cauliflower growing in gardens the possibilities for the production of that crop on a commercial scale would appear to be good.

The following crops are also grown in favored localities with very good results: Cabbage, turnips, rutabagas, cucumbers, radishes, beets, carrots, pease, beans, citrons, pumpkins, squash, and strawberries.

Green tomatoes for pickling are also grown, but unless the plants are transplanted from a greenhouse the seasons are a little too short to mature this crop. Sweet corn does well, but the seasons are too short for field corn.

The chief value of this soil will be for special crops, like potatoes or cauliflower, and, in fact, nearly all kinds of light truck crops. It is not well adapted to general farming and is too light for profitable crops of the cereals and grasses. Clover and timothy do fairly well in the low areas, where the moisture conditions are favorable.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Miami sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11921	Solon Springs	Gray incoherent sand, 0 to 8 inches.	3.1	27.6	27.4	26.0	4.1	7.1	4.7
11923	2 miles SW. of Solon Springs.	Red incoherent sand, 0 to 8 inches.	3.2	32.4	27.9	21.4	3.1	6.9	5.0
11922	Subsoil of 11921	Red incoherent sand, 8 to 40 inches.	3.8	24.2	32.2	32.6	3.1	1.8	2.1
11924	Subsoil of 11923	Red incoherent sand, 8 to 36 inches.	3.7	29.2	33.8	26.3	1.5	2.9	2.5

DUNESAND.

This type consists of several feet of loose, incoherent fine to medium sand, with no difference either in color or texture to a depth of 40 inches or more. It is found at the head of Lake Superior, in the vicinity of the cities of Superior and Duluth, and occurs as a series of low-lying bars varying from a few feet to several rods in width. The largest and most important of these bars forms the excellent natural harbor of Superior and Duluth.

The existence of these bars and points is due to the combined action of waves and wind upon the sands brought down by the St. Louis River and deposited in the shallow water at the head of the lake. The sands are first piled up by the waves and later shifted by the winds. The areas covered by the type are limited in extent and almost devoid of vegetation. They have no agricultural value.

The following table gives the results of a mechanical analysis of a sample of the Dunesand:

Mechanical analysis of Dunesand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11945	Minnesota Point, Minn.	Gray sand, 0 to 40 inches.	0.0	5.5	49.0	44.2	0.6	0.4	0.3

ROUGH STONY LAND.

The interstitial soil of the Rough stony land is a very fine sandy loam or silty loam. The only apparent difference in soil and subsoil is that the former has a little less organic matter than the latter. The surface of the ground is so strewn with bowlders that one can in most places easily step from stone to stone. In fact, about 70 per cent of the surface is covered with rocks, the size of which ranges from 6 inches to 5 feet in diameter.

This type occupies the tops and slopes of the hills back of Duluth, and is characteristically developed in the vicinity of Duluth Heights. It is found only as a strip of country from 2 to 4 miles wide north of the rock outcrop areas. To the northward it passes gradually into a much better agricultural region, where the same general character of material is found, but with less rock.

The surface features are rough, hilly, and broken, and the drainage is excessive. The type is derived from material laid down or reworked by torrential floods at the close of the glacial period. The movement of the waters was greatly accelerated as they reached the slope of the hills above the lake, and all material except rocks and bowlders was borne along with the water. As shown in road cuts and borings, the number of rocks and bowlders diminishes rapidly at a depth ranging from 2 to 4 feet below the surface.

Except in a few favored patches, which are used for growing vegetables, the land is too rough, stony, and droughty to be of any value for farming. During part of the year it furnishes a fair pasture for cattle.

ROCK OUTCROP.

Under the head of Rock outcrop are classed all areas where the underlying rock of the region is exposed, or is so near the surface as to render the soil too stony and droughty for anything except a scanty vegetation.

In Douglas County, Wis., such areas are found in a few places along Douglas Range, while in Minnesota a strip occurs within the city limits of Duluth, covering a ridge rising abruptly to 600 feet above the lake.

These outcrops belong to the oldest rocks on the continent, and consist principally of a series of lava flows of the lower Keweenawan formation.

Within the city limits of Duluth there are patches of red clay from 1 to 4 or 5 acres in extent, which was deposited in the depressions or " pockets " on the hillside when the lake stood at a higher level. This clay has not been entirely removed by erosion, and is more or less mixed with rock fragments and gravel. A few patches of gravel, remnants of the ancient beach and deltas, also occur as a veneering upon the rock outcrop areas in Duluth. The rock, gravel, and sand are used locally for building purposes and street construction. The type has no agricultural value.

MUCK.

The Muck is a mass of roots, fibers, and moss in various stages of decomposition, and varying in depth from 1 to 15 feet. In the deepest areas there is little difference in color or texture to a depth of 3 or 4 feet. Below this the structure of the organic matter is not so apparent, and the whole mass is more thoroughly decomposed.

The Muck is found in large bodies in the southern part of the area, principally in the Miami sandy loam areas. It occurs as low-lying, level tracts, which were formerly lakes or depressions, but which have been built up into level areas by the accumulation of organic matter.

The drainage of these areas is naturally poor, and the material is always saturated with water. Since the timber of the adjoining region has been largely removed and ditches have been constructed along some of the county roads, many of these swampy areas have become dryer, and some shallow lakes have been converted into swamps. Undoubtedly most, if not all, of these areas may be drained by artificial means.

This soil is the result of drainage and climatic conditions that tend to retard the decomposition of organic matter. At the close of the glacial period ponds and shallow lakes doubtless occupied the depressions now mapped as Muck. Vegetation gradually encroached upon these, and the accumulation of moss, sedge grass, leaves, and trunks of trees was more rapid than the natural processes of decay.

In most regions the muck areas are among the last to be reclaimed. In a newly settled country they are usually held in low esteem, probably because of the expense involved in draining and preparing them for cultivation. In Ohio and Michigan such areas, when reclaimed, are used extensively for onions and celery and are valued at from $100 to $200 or more an acre. As yet practically none of the type has been brought under cultivation in the Superior area.

AGRICULTURAL METHODS.

Twenty years ago the whole of the Superior region was covered with heavy coniferous and hardwood forests, but now nearly all the merchantable timber has been removed and the slashings have been further cleared by forest fires.

The first attempts at growing crops were upon small clearings in the midst of the timber, and the results were not very encouraging, owing, it is believed, largely to the fact that with the short summers the soil in small fields surrounded by tall forests dries and warms up very slowly. Since the clearings have been extended the crops have done much better. The first crops were sown or planted among the stumps, the surface of the ground being merely scratched in the preparation of the seed bed. These stump fields were satisfactory enough for pasture, but very unsatisfactory for cultivated crops. The hardwood stumps standing among the grass of meadows are easily removed in a few years, but the large white pine stumps, with their great sprawling roots, would long outlast the settler were it not for the use of the stump puller and dynamite. The clearing of every acre requires hard labor, and the cost per acre varies greatly with the type of soil, the length of time since the original forest was removed, and the judgment of the persons doing the work. The average cost of clearing the land of stumps and stones, including the first plowing, is between $20 and $30 an acre.

During the last few years considerable permanent improvements have been made. The stumps and stones upon some farms have been entirely removed and the soil is being tilled in accordance with modern methods. The first crops after deep plowing upon new ground are apt to be unsatisfactory, because the coarse litter, when turned under, forms a layer between the soil and the subsoil, thus destroying the capillary connection between the two. The first plowing should be shallow, and should be followed by some cultivated crop like potatoes. The following year the land should be sown to some cereal, to be followed by clover. After the coarse litter has been broken up and well worked into the soil deeper plowing can be safely resorted to.

As yet little attention has been paid to the matter of plowing different types of soil at different seasons and to different depths. On the Superior clay especially it is desirable that plowing be done in the fall after the heavy rains, so that the soil may be exposed to the action of frost during the winter and may be ready for planting as early as possible in the spring. In this type it would also be well to plow the fields in narrow lands in the direction of the slope, thus facilitating drainage. Better results will also be obtained with this soil if the crops be rotated with clover, the long, fleshy roots of which open the soil and improve the drainage and the circulation of air.

A great deal can be done by the use of better methods of cultivation to conserve the moisture in the sandy types of soil, but even with the most careful methods the Miami sand would better be used for the production of special crops like potatoes, cauliflower, cabbage, sweet corn, and root crops, rather than for general farming crops.

Upon the Superior clay hay farming has been such a profitable source of income that some tracts are being purchased to be used for the production of hay on a large scale to supply the local markets. No system of rotation is being planned in connection with these hay farms. It is thought that since clover has been known to grow for over twenty years in the openings and around old logging camps, it may also be grown year after year without reseeding. Such a system of farming will eventually exhaust the soil, and the plan should be changed to include other crops and the raising of livestock, and, in fact, some form of animal husbandry should be included in the farming operations throughout the area in whatever type of soil. The greater portion of the hay and straw produced upon the farm should be consumed there; the manure should be well cared for and returned to the fields, and this, together with the growing of clover, should be sufficient to keep the soils in a permanently productive condition. Too much stress can not be laid upon the desirability of raising stock both for dairy and beef purposes in the lake basin portion of the area, where the soil is heavy, cold, wet, and difficult to work. Here dairying might be made the chief industry, while farther southward, in the sandy types, it should be an important auxiliary to general farming. Throughout the area the natural conditions are favorable to dairying. The nights are always cool; there is an abundance of cool spring water and flowing streams, and ice is never necessary. The red clay of the lake basin is especially adapted to pasture, while throughout the area pastures remain green until covered with snow—at least one month longer than farther south in the State—which fact compensates for the later date at which stock may be turned out to pasture in the spring. There is a great temptation to produce hay at the present prices, and the expense of keeping stock through the long, cold winter is considerable, but this expense can be greatly reduced by housing the cattle in modern stock barns, and, moreover, dairy products command the best prices in the near-by markets of Superior and Duluth, so that taking everything into consideration there should be as much, if not more, profit in dairying as in growing hay for sale.

AGRICULTURAL CONDITIONS.

The farm operations of the area are carried on largely by people who started without capital and without a proper knowledge of farming, and who, until recently, owing to the great demand for unskilled labor, were employed for all or a great part of the time in the shipyards, ore docks, and steel plants at Duluth and Superior. Others among the original settlers worked in the near-by lumber camps during the greater part of the year, and some found employment on the county roads, in the meantime neglecting the improvement of their farms.

The settlers from Iowa, Illinois, and Indiana, on account of their familiarity with American methods of farming, have made the best showing. Those from Sweden, though they make good citizens, are not usually progressive farmers. Their present conditions are so much better than those of the Old World that they are content with what they can make from small farms of from 20 to 40 acres. This is the case to an even greater degree with the settlers from Finland.

During the period of business depression following 1893 a few of the laboring class from Superior and Duluth moved to farms in the country adjoining, and these have been prosperous. The country has not been sufficiently developed to show great increase in individual wealth, but many farmers, starting without capital, have by industry and economy established for themselves permanent homes. With the development of the country these pioneer farmers will profit by the natural increase of land values.

Practically all farms are operated by the owners, and there will be little reason for renting farm lands here as long as the low price of virgin land continues. The price of unimproved land ranges from $3 to $15 an acre, depending upon the type of soil and the location with respect to the towns and railroads. There is an abundance of land which can be obtained upon easy terms and in any quantity desired. Large tracts formerly timbered, however, are still held by lumber companies, who expect the settlement of the surrounding country to enhance the value of their holdings. Some of these lands can not be purchased in smaller parcels than one section or more, thus placing them beyond the settler of limited means. Formerly some of the lumber companies were unwilling to sell lands to settlers, probably for the reason that the increased rate of taxation incident to the development of the country might be excessive on their remaining undeveloped tracts. There is also considerable farm land in the country back of Superior which is held by eastern capitalists, who, having purchased it at "boom" prices, are unwilling to dispose of it for what it is worth for farm purposes.

The farms under cultivation range in size from 20 to 250 acres, with an average of about 100 acres. The holdings of unimproved lands range from a few acres up to 10,000 acres or more.

In the present stage of development of the area very little farm labor is hired, practically all of the work being done by the settler and his family. To the disadvantage of their farms, many of the settlers still spend a considerable part of the year in the lumber camps or working upon the county roads, but more labor is now being directed to clearing the land and founding permanent homes than formerly, owing to the decreased opportunities for work, and this tendency will become more and more marked from this time forward. The removal of the timber has made it less difficult to clear the land for cultivation, and agriculture has a much better footing now than it could possibly have had if the timber companies had not first exploited the heavy forests.

The products of the area are clover, timothy, potatoes, wheat, oats, rye, barley, sweet corn, pease, beans, the root crops and other vegetables, and berries. As already stated, field corn as yet can not be successfully grown, and tomatoes do not ripen unless started in a hot bed and transplanted.

The adaptation of the several soils to these crops and the opportunities for specialization being important conclusions in the survey work, will, at the risk of tiresome repetition, be summarized in a few succeeding paragraphs.

The Superior clay is especially adapted to the production of clover and timothy, the average annual yield when grown together being 2½ tons per acre. Wheat, under the most favorable conditions, will yield as much as 30 bushels per acre, but the average yield is probably not more than 15 bushels. Oats will average about 35 bushels per acre, but much larger yields are not uncommon. Oats have a tendency to rust upon this type of soil, probably because of the dampness from the lake. Potatoes and all root crops do well when well cared for, but the quality of the potatoes is not the best. Blackberries, raspberries, currants, and gooseberries do fairly well. This soil is excellently adapted to pasture.

The Superior sandy loam is the most desirable soil type in the area for general farming. It is usually very difficult and expensive to clear, owing to numerous large pine stumps, but when once under cultivation it is better adapted to all such crops as are grown in the region than any other soil type in the area.

The Miami sand is not naturally a productive type, but by careful methods of cultivation and the application of barnyard manure it is recognized as a very desirable type for all kinds of root crops, cabbages, cauliflower, and sweet corn. In many places this type is apt to be deficient in moisture owing to the loose, open texture of the soil and subsoil materials, and this droughtiness makes it a poor soil for hay or pasture.

The Miami sandy loam is a type fairly well adapted to all general farm crops of the area. The soil is a little more compact than the subsoil at 24 inches, but at a depth of about 4 feet the type is underlain usually by a compact sand which is quite retentive of moisture. It is recognized as a safe soil for potatoes and all root crops, and produces a fine quality of cabbage and cauliflower. It is better adapted to hay and pasture than the Miami sand, but is not so desirable for those purposes as the Superior sandy loam and Superior clay. It is an excellent soil for berries, especially strawberries.

Very little of the muck of the area has been drained and put under cultivation, but in Ohio and Michigan and other parts of Wisconsin it is one of the best types for celery and onions. The few attempts so far made to grow these crops upon the muck areas of the Superior area indicate that they will also do well here.

The Rough stony land type is undesirable for anything except pasture. In a few places small patches have been cleared of stumps and stones and are being utilized to supply the Duluth markets with vegetables.

With the exception of the swamp region south of the Douglas Range in the southwestern part the area is well supplied with railroads. Considering the state of agricultural development in the area, the county roads are good. They are often far apart, but are ample to meet the present demand. In wet weather the red clay roads are well-nigh impassable for heavy loads, and much of the hay is marketed after the ground freezes, but the roads are usually in such condition that light loads of truck crops may be marketed.

The rapid growth of the cities of Superior and Duluth has caused an increase in the demand for all farm crops far beyond the ability of the adjoining country to supply. The only crop thus far produced in quantities approaching the demand is hay, but hundreds of carloads are still shipped in annually. There is a ready demand for all farm products, and the prices are good.

SOIL SURVEY OF TAMA COUNTY, IOWA.

By CHARLES W. ELY, GEORGE N. COFFEY,[a] and A. M. GRIFFEN.

LOCATION AND BOUNDARIES OF THE AREA.

Tama County lies nearly in the center of the State of Iowa. It is bounded on the north by Blackhawk and Grundy counties; on the east by Benton County; on the south by Poweshiek County, and on the west by Marshall and Grundy counties. It lies between the meridians of 92° 17′ 30″ and 92° 47′ west longitude, and the parallels of 41° 51′ 45″ and 42° 16′ north latitude, and has an area of 720 square miles.

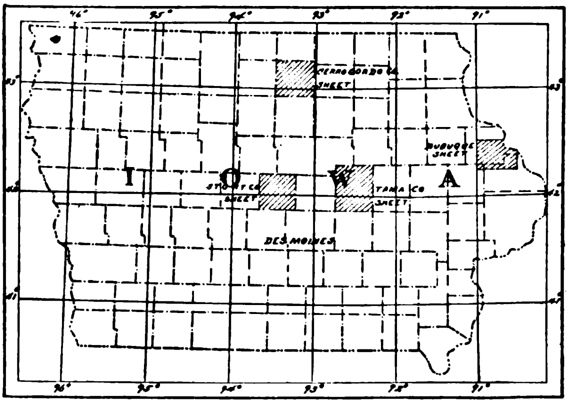

FIG. 32.—**Sketch map showing location of the Tama County area, Iowa.**

The town of Tama, situated in the southern part of the county, is 270 miles west of Chicago and 220 miles east of Omaha. The main lines of both the Chicago and Northwestern and the Chicago, Milwaukee and St. Paul railways pass through this place.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Tama County was first settled in 1848, and by 1853 large numbers of immigrants had come in from Ohio, Indiana, and Illinois. There was also some immigration from Europe. In 1853 Tama County was organized, being detached from Benton County.

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[a] When about half of the area had been surveyed it was necessary for Mr. Ely to absent himself from the work, and Mr. Coffey was placed in charge of the field work and carried it to completion.

The early settlers were attracted to the timber lands, covered with oak, elm, hickory, and hazel brush, which occupied the hills and bluffs along the Iowa River and other streams in the southern part of the county. These lands offered abundant building material for dwellings and fences, and also afforded protection from the cold winter winds which swept down from the prairie country to the north.

The staple crops of the early settlers were wheat and corn. Flax was also raised to some extent. Sheep were raised for wool, which supplied material for the homespun clothing of the period. Sheep raising was attended with some difficulties, as wolves were numerous and killed many sheep. Many of the settlers depended largely upon game for sustenance.

Prior to the advent of public roads communication in this undeveloped country was very difficult, and each community lived in a state of practical isolation. The first State road in the county was built along the south side of the Iowa River in 1853 and extended from Marengo to Fort Dodge. Dubuque was the early market for the northern half of the county and Muscatine for the southern half. On account of the distance to these points and the inadequate transportation facilities available at that time only a few trips were made annually. The Mississippi and Missouri River Railroad was extended to Iowa City about 1850, and the Chicago and Northwestern Railroad reached Tama in 1863. These two roads assisted very materially in the development of the county. The Chicago, Rock Island and Pacific Railroad reached Traer in 1872. With the advent of railroads settlement increased rapidly, and by 1875 nearly all the land in the county had been taken up and inclosed.

For a time there had been a large amount of timber land along the streams and the prairies had remained untouched. As the country became more thickly settled, however, all the timber land was taken up and the prairies began to be utilized. At first they were used for pasture, but as fast as they could be fenced the sod was broken and crops were planted. In 1875 there were only 75,000 acres of original timber land in the county, and most of this has since been cleared off, so that what now remains is chiefly second growth.

For a great many years after the first settlement spring wheat proved a reliable, profitable, and easily marketed crop, and it was grown year after year on the same soil without rotation until the yields finally fell below the limit of profitable production. In 1875 there were more acres in wheat than in corn. The early settlers raised but little stock, as they had few fences, and were constantly menaced by wolves; but as farms were improved and fences extended the number of farm animals increased, and this created a demand for corn and other feeding grains. Wheat gradually ceased to be grown, and the chinch-bug plague of 1882 practically put an end to its cultivation in this section. At present some sentiment exists in favor of including it in the system of crop rotation, as it is generally recognized that lack of rotation has been largely responsible for the decreased yields.

The cultivated fruits, especially pears and apples, were grown quite extensively for home use in the earlier days, but in late years few new orchards have been planted and the old ones have ceased to bear, so that very little fruit is seen. An attempt is being made at the present time to grow small fruits for the local markets on some of the hilly areas in the county, and thus far the venture appears to have been quite successful.

Since the decline of wheat growing there has been a tendency to raise more live stock, especially beef cattle and hogs, which are shipped to eastern markets.

CLIMATE.

The following table, taken from the records of the Weather Bureau stations at Toledo, Belle Plaine, and Grundy Center, shows the normal monthly and annual temperature and precipitation for this region. Toledo, the county seat, is a few miles southwest of the center of the county; Belle Plaine is just outside the southeast corner, and Grundy Center is a few miles north of the northeast corner of the county.

Normal monthly and annual temperature and precipitation.

Month.	Toledo.		Belle Plaine.		Grundy Center.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	°F.	*In.*	*°F.*	*In.*	*°F.*	*In.*
January	19.7	0.81	18.3	1.55	16.5	0.66
February	19.6	.69	20.8	1.21	17.8	.71
March	33.2	1.75	32.0	2.52	30.9	1.61
April	49.9	3.17	45.6	3.70	47.7	3.53
May	61.8	3.71	59.0	4.22	58.3	4.72
June	70.7	3.60	70.3	3.99	66.5	4.91
July	74.9	3.23	73.6	3.42	72.4	3.76
August	72.9	3.15	70.8	3.49	71.0	3.00
September	64.6	2.94	64.1	2.67	63.3	3.20
October	52.4	1.96	50.4	2.23	51.3	2.77
November	35.2	1.41	33.7	1.72	32.1	1.18
December	23.6	1.09	24.3	1.41	22.5	1.21
Year	48.2	27.51	46.9	32.13	45.9	31.26

The total precipitation is somewhat less than the average for the humid section, but its distribution through the growing season produces better crops than might result from a much heavier rainfall occurring more largely in the winter months. Over 70 per cent of the rainfall occurs during the seven months from April to October, inclusive.

Based on the records of the three stations given in the table, the average date of the last killing frost in spring is May 3, and that of the first in autumn is September 28, which gives a growing season of 148 days.

PHYSIOGRAPHY AND GEOLOGY.

The mean elevation of Tama County above sea level is approximately 925 feet. Berlin, located near the northwest corner, has an altitude of 1,056 feet, and is about the highest point in the county. Dysart, in the northeastern part, and Tama and Chelsea, in the southern part of the county, have elevations of 958, 827, and 789 feet, respectively.

The drainage of most of the two northern tiers of townships is toward the east through Wolf Creek, and ultimately into the Cedar River. Aside from this section, the drainage of the entire county passes into the Iowa River. Sugar Creek drains most of the southeastern portion north of the river, and Deer Creek the southwestern part. The Iowa River flows through the county in a direction somewhat south of east, and leaves it near the southeast corner. Richland Creek, the only tributary of any size south of the river, flows almost directly east. These streams all flow in preglacial valleys excavated from the rock long before the invasion of the glacial ice. Since then these valleys have become partially filled by débris left by this ice, so that at present the streams are characterized by low flat bottoms, much too large for the present volume of the stream, and broken only rarely by sloughs. Through these bottoms the water winds in a series of curves and bends, with occasional cut-offs, this characteristic being especially marked in the Iowa River. Many of these streams have one-sided basins, a large number of long streams entering from one side and a few short streams from the other, while the major stream flows along one side of the basin which it drains. Several explanations have been suggested for this condition, none of which are entirely satisfactory.

The topography of most of the northern half of the county is that of a very gently rolling to almost level prairie. The lesser streams rise in small marshy areas and have cut almost no channels in the surface. Nearly all the draws are wet, even during the summer, and need artificial aids to drainage in order to obtain the best results. Spring Creek, Lincoln, and Grant townships, much of Buckingham, Perry, and Clark townships, and the southern part of Crystal Township are of this character. Geneseo Township is somewhat more rolling. A more or less well defined morainal ridge is found just north of Wolf Creek in this township, and a few scattered hills of this character, rising from 20 to 40 feet above the surrounding prairie, are seen in the southern portion of the county. Another morainal ridge extends along the north side of Wolf Creek from Traer westward for a distance of 7 miles. Except for these variations, the gently rolling character of the country extends down to the stream bottoms. Along these moraines the bluffs rise from 40 to 50 feet above the stream, and erosion has developed deep gullies and ridges opening toward the stream.

The southern half of the county is much more broken than the northern half. A somewhat sinuous line of hills enters the county near the southwestern corner of Carlton Township and extends a little north of east to Deer Creek, where it follows the Iowan moraine along the creek for a distance of 4 or 5 miles. Between these hills and the Iowa River and Deer Creek the country is rugged and hilly, the bluffs rise from 40 to 70 feet above the bottoms, and the numerous small streams have cut deep V-shaped gullies through the hills, making the country a succession of deep gullies and sharp ridges, though occasionally a flat area, from one-eighth to one-fourth of a mile in width, is found on the tops of the hills. The same is true of the area of Miami silt loam inclosed by Salt Creek and the Iowa River and of other places where it occurs in the county. The most hilly sections of the county, however, are the two areas which have been specifically described.

In the southern part of the county the surface of the Marshall silt loam is more billowy. There is a general absence of the small marshy areas in which the lesser streams take their rise, and natural drainage is better established than in the northern part. A number of scattered rounded morainal hills, rising from 30 to 40 feet above the surrounding prairie, are seen in Howard and Toledo townships. The country south of the river, aside from the bluffy and hilly portions, is characterized by a series of low ridges and rises, running approximately east and west between the streams. Artificial drainage is rarely necessary, except in the bottoms, since practically the entire body of the uplands is rolling enough to carry off the surplus water. However, in the extreme southern portion the country becomes almost level again, and some tile are used in the extreme southern and southwestern sections. A well-marked moraine, 20 to 40 feet high, extends a few miles eastward into the county from the southwestern corner of Indian Village Township. Along most of its course the Iowa River is lined with gullied bluffs; so also is much of the north side of Richland Creek, while in other places the gently rolling or sloping country extends to the stream bottoms.

The basal structure of most of Tama County is made up of rocks of the Lower Carboniferous series. None are exposed except in the western part of Carlton and Indian Village townships, where some Kinderhook limestone is seen. A small area of Des Moines is also seen in the latter township. Over the remainder of the county the rocks have been buried from 50 to 200 feet deep by a layer of glacial drift and loess. Exposures in other parts of the State, however, indicate that the northeastern corner of the county is underlain by Devonian rock.

This area has experienced three invasions of the ice sheet. The first of these was the pre-Kansan glacier, of which few remains are seen. This was followed by the Kansan, which ground down the rock surfaces, filled up the valleys, and covered nearly the entire county with a layer of drift from 50 to 200 feet thick. This ice sheet carried an immense amount of débris. After its retreat there was a long interval of time in which drainage channels were developed and severe erosion took place. This eroded Kansan drift covered by loess is seen in Carlton Township, in the northern part of Indian Village Township, in the northwestern part of Toledo Township, in nearly all of Carroll and Otter Creek townships, in the western part of York and Salt Creek townships, in the southern part of Richland Township, and in the northern part of Columbia Township.

While a very small part of the soils of this area is formed directly from the Kansan drift, the hilly topography, where it is not covered by the later Iowan, has favored the development of the Miami silt loam rather than that of the Marshall silt loam after the loess was deposited, by giving ready drainage and preventing the wet and slightly marshy condition which must have obtained in the prairie for a long time. In the areas just mentioned it is thought that the topography of the Kansan is much the same as it was before the advent of the Iowan ice. The latter did not cover all of the county, but extended over most of the northern half. A lobe extended down to the river in the vicinity of Tama and Toledo and another reached from Marshall County eastward into Highland Township. This ice did not carry so much drift, but planed down the eroded surface of the Kansan, leaving the country level or only gently rolling and the conditions favorable for the formation of the prairies.

Over the entire county, except in the bottoms, and covering both the Kansan and Iowan drifts, has been spread a layer of almost pure silt or loess from 3 to 30 feet thick. The exact method of this deposition is unknown, but it is thought to be the finely ground-up particles of rock carried by the glacier, which, as it retreated, left deposits to be scattered by the waters and wind, probably in this case largely by the wind. From this covering of loess all the soils in the uplands, except the Miami fine sand and the Marshall loam, have been derived. The Marshall silt loam was formed under slightly wet conditions, which favored the growth of the prairie grasses and the consequent incorporation of organic matter, while the Miami silt loam was formed under conditions practically the reverse.

SOILS.

Five types of soil were recognized in this area. The actual and relative extent of each is shown below:

Areas of different soils.

Soil.	Acres.	Per cent.
Marshall silt loam	308,288	66.9
Miami silt loam	76,224	16.5
Kaskaskia loam	70,592	15.3
Miami fine sand	3,968	.9
Marshall loam	1,728	.4
Total	460,800	

MARSHALL SILT LOAM.

The Marshall silt loam is distinctly a silty soil and is very uniform. Except for small differences in the content of organic matter and the depth of soil, a sample taken from one place in the area is identical with one taken from any other place. To a depth of from 16 to 24 inches there is a dark-brown, friable silt loam, free from either stones, gravel, or sand. When dry it has a somewhat ashy appearance, but when very wet it is in some places almost black in color. It has a slight plasticity when damp, yet does not bake. Unless stirred at the wrong time it is friable and easily broken up, and farmers encounter no difficulty in preparing it for crops. In some instances the soil takes on a slight reddish tinge below the plow line, which continues to the yellow subsoil. In other cases the soil is exactly the same all the way down. On the more rolling areas, especially in Toledo and Highland townships, the soil has been washed to some extent. The yellow subsoil comes to within 16 inches of the surface, and the ground has a reddish-brown tinge instead of the typical clear brown.

The subsoil is a yellow, slightly clayey silt, slightly plastic like the soil when very wet, but friable when dry and easily broken up. It is similar in texture to the soil, the chief difference being in the amount of organic matter present. The subsoil, when very dry, shows some tendency to break up into angular clods one-fourth of an inch in diameter, and usually cubical in form. This material, generally called "yellow clay" by the farmers, varies from 3 to 30 feet in thickness, the greater part being about 5 feet thick.

The particles of which both the soil and the subsoil of this type are composed are mostly of one size, known as "silt," and intermediate between sand and clay. Even when the clods are exposed to continued rains no particles of sand are seen on their surface. When cultivated the clods are easily broken apart, and the soil is put in a fine condition of tilth. The fineness of the grains of soil is such as to afford a large feeding surface to the roots of plants and enables the soil to hold a considerable amount of moisture. This property is further increased by the organic matter in the soil, and yet, unless very level, the soil permits the water to percolate downward, and even the most level portions are easily drained artificially. To these desirable physical properties the Marshall silt loam owes a very large measure of its productiveness.

Practically all the northern half of the county is covered with this type of soil; also nearly all of the area south of the Iowa River. Lincoln, Grant, Clark, Springfield, and Highland are townships in which almost no other soil type is found. Small areas occur on the crests of hills in the more hilly portions of the county.

The surface of the Marshall silt loam is that of a level to gently rolling prairie. It is more rolling toward the streams and the boundaries of the Miami silt loam. In the more level areas are numerous small seepy and marshy places, and draws, down which at times streams flow. During the greater part of the year these places are too wet to be cultivated and are left in grass. Most of them are comparatively narrow, and one tile drain down the center would fit them for cultivation, at the same time aiding the surrounding land to withstand excessive rains without injury to crops. This is one improvement which deserves the immediate attention of the farmers of Tama County. Something has been done already in this direction, but the work should not stop until every wet, marshy area is tile-drained. Most of that body of the Marshall silt loam lying south of the river is well drained naturally, as its topography is more rolling than that of the northern portion. Even here, however, tile drains judiciously used would prove a paying investment, especially in the extreme southern and southwestern portions of the county.

This soil type is derived by weathering from the loess which covers practically all of Tama County. It was originally covered with prairie grass and its present dark color is due to the organic matter which has been incorporated in the soil. Its level character prevented washing and kept the soil more or less damp, so that decomposition was not very rapid and any organic matter once in the soil remained there for some time. The difference between this type of soil and the Miami silt loam is largely one of organic matter, and this has been brought about by the difference in topography and in native vegetation. When cultivated for many years without manures or rotation of crops this soil loses organic matter and takes on a reddish tinge, especially when subject to washing. The particles of which this loess is composed are ground-up fragments of rock only partially decomposed, and the separate minerals are easily detected by microscopic examination.

Corn is the principal crop on this type. The average yield is between 40 and 50 bushels per acre, while yields as large as 70 and 80 bushels are often reported. Oats are second in importance, averaging slightly less than corn in the number of bushels per acre. Barley, rye, and wheat are grown to some extent. Hay is an important crop, averaging from 1½ to 2 tons per acre. The Marshall silt loam was formerly considered a good wheat soil, but little is grown at the present time. Some areas are seeded down to pasture. Very little fruit of any kind is seen.

It is difficult to imagine a type of soil better adapted to general farming than the Marshall silt loam. It is an almost ideal soil for corn and oats. Wheat does well where rotation of crops is practiced. Clover and alfalfa are cultivated successfully in some sections.

The following table gives mechanical analyses of typical samples of this type:

Mechanical analyses of Marshall silt loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10858	2¼ miles W. of Traer.	Brown silty loam, 0 to 22 inches.	0.1	0.7	0.4	0.6	5.9	74.2	18.1
10860	¼ mile E. of Toledo.	Brown silty loam, 0 to 18 inches.	.1	.5	.4	.9	6.7	66.9	24.4
10862	1¼ miles W. of Gladbrook.	Brown silty loam, 0 to 17 inches.	.0	.3	.2	.5	6.4	67.2	25.3
10863	Subsoil of 10862 ..	Yellow clayey silt, 17 to 36 inches.	.1	.3	.1	.6	9.0	68.4	21.6
10859	Subsoil of 10858 ..	Yellow clayey silt, 22 to 36 inches.	.1	.7	.3	.6	9.2	65.6	23.4
10861	Subsoil of 10860 ..	Yellow clayey silt, 18 to 36 inches.	.0	.2	.3	.9	7.0	67.0	24.4

MIAMI SILT LOAM.

On the hills and bluffs along the Iowa River and other streams a different type of soil has been developed, although the material from which it is derived is the same as that from which the Marshall silt loam has been formed. This condition has also been noticed in other areas, and the names Marshall silt loam and Miami silt loam have been used to distinguish the two types. The Miami silt loam consists of a light-gray, mealy silt loam about 12 inches deep, underlain by yellow, somewhat compact, clayey silt, which is practically identical with the subsoil of the Marshall silt loam. In the field, however, it is apt to be drier, and hence shows a greater tendency to break up into cubical masses. This is more marked during dry weather and in late summer, when it is quite common to find the third foot down very dry and hard.

The type was originally timbered with oak, hickory, elm, maple, and hazel brush. Where this has never been cleared away, the soil from 3 to 6 inches is a light-brown or gray silt loam, similar to that seen in some places in the Marshall silt loam, yet feeling more loose and mealy, and apparently containing more fine sand. Underneath this is a yellowish silt loam of the same texture, but without the organic matter, which is underlain at 8 to 14 inches by the usual clayey silt subsoil. When plowed the two layers of soil become mixed and a more or less uniform gray silt is formed. When cultivated for a few years without manure, the extreme phases of this soil tend to become white and chalky after a few warm, dry days. The greater part, however, is gray in color, except on the badly washed hillsides, where the yellow subsoil has been exposed. Farmers usually speak of this soil as "hills," "clay land," or "timbered land," to distinguish it from the prairie.

Aside from the difficulties due to topography, the Miami silt loam is easily cultivated. The fineness of the particles gives the soil a fair moisture-retaining capacity, but without the stickiness and coherency of a clay. Hence they are easily broken apart unless handled when very wet. This same quality, however, permits easy washing, and the steep hillsides are rapidly eroded if left exposed.

The largest areas of this type are found on the hills north of the river and west of Deer Creek, in Indian Village, Carlton, and Toledo townships; north of the river and west of Salt Creek, in York, Otter Creek, Salt Creek, and Carroll townships, and on the south side of the river in the eastern part of the county. Smaller areas are found elsewhere.

The Miami silt loam occupies the most hilly land in the county. All the smaller streams have cut deep V-shaped gorges from 40 to 70 feet deep, so that a succession of steep hillsides and valleys is presented. Sometimes gorges are seen whose stream beds are dry except immediately after a rain. Occasionally narrow, flat, and rounded hilltops are found almost surrounded by gullies and sharp ridges.

In these cases only the more level hilltops are cultivated, and the slopes are left in pasture. The most hilly areas are those directly north of Montour and Chelsea. Viewed from the top of a ridge, the surrounding country appears to be of the same height. This would indicate that the hills and gullies might have been carved out of a region once nearly level.

This topography would of itself give good natural drainage, even if the slightly open character of the soil did not permit water to pass down to some extent. The soil does not suffer during rainy seasons save from washing. Many farmers claim that for a series of years it will yield as good returns as the other types of soil. When planted to cultivated crops, such as corn, or left untilled, this soil is subject to much washing, and the most careful management is required to prevent damage from this source. Much of it is underlain at no great depth by a sandy or gravelly glacial till, which is not likely to prove so productive as the present soil, and if cultivated to corn it is only a question of time when this underlying material will be exposed in a great many places, to the serious detriment of the land. Gullies, too, may form and damage the fields.

As already stated, the Miami silt loam is derived from the same loess layer which formed the Marshall silt loam. The Miami silt loam was originally timbered land, and the decay of the roots and leaves of the trees did not add so much organic matter to the soil as did the prairie grass which originally covered the Marshall silt loam. The better drainage of the former soil caused more rapid oxidation of what organic matter there was, so that at present the principal difference between the two soil types lies in their topography and in the amount of organic matter which they contain.

Practically the same crops are grown on this type as on the Marshall silt loam. Corn yields from 30 to 50 bushels per acre and other crops in proportion. Probably one-third of the Miami silt loam in the area is still in timber and pasture. A few strawberries are grown on the tops of the ridges, where the topography gives good atmospheric drainage and there is less danger from frosts than elsewhere. The Miami silt loam is well adapted to apples, pears, and small fruits, to pasture, and, in the less hilly portions, to the general crops of the area. Good yields of wheat should be secured from this soil. The steep hillsides should be seeded down to pasture and broken up, if at all, only at long intervals. Much attention should be given to the incorporation of organic matter in the more level portions by the use of manures and by the turning under of green crops. If this were done for several years, the Miami silt loam would become a very productive soil.

The following table gives mechanical analyses of typical samples of the Miami silt loam:

Mechanical analyses of Miami silt loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10870	5 miles NE. of Toledo.	Gray silty loam, 0 to 6 inches.	0.1	0.4	0.3	1.1	13.6	67.6	16.9
10872	3½ miles N. of Montour.	Gray silty loam, 0 to 12 inches.	.0	.3	.2	.7	9.1	70.2	19.0
10874	7 miles W. of Vining.	Gray silty loam, 0 to 11 inches.	.0	.3	.2	.7	7.4	71.7	19.7
10875	Subsoil of 10874	Yellow clayey silt, 11 to 36 inches.	.0	.2	.2	.4	5.7	72.6	20.7
10871	Subsoil of 10870	Yellow clayey silt, 6 to 36 inches.	.0	.1	.1	.4	9.5	68.3	21.5
10873	Subsoil of 10872	Yellow clayey silt, 12 to 36 inches.	.0	.2	.1	.3	7.8	68.7	22.9

KASKASKIA LOAM.

In the broad bottoms which characterize most of the streams of this area a soil considerably darker than any of the upland types is found. The Kaskaskia loam is a dark-brown loam carrying a comparatively high percentage of silt, which gives it many of the characteristics of a heavy silty loam. This material is from 18 to 36 inches deep and is underlain by a drab heavy loam or silty clay. The soil is deeper along the smaller streams, the depth in most cases exceeding 36 inches. It contains more coarse and fine sand than either of the preceding types, as is readily seen when the clods are exposed to the rain for some time. Its color is darker than that of any other soil within the area and the content of organic matter is greater. It granulates and falls to pieces readily when cultivated at the proper time, yet if plowed when wet forms very hard clods. Roads over this type in winter and early spring and during wet seasons become very muddy and sticky and are sometimes almost impassable. If badly cut up, they become almost as hard as rock when they dry out. It is necessary to rework the roads every spring.

The soil is somewhat more silty along the smaller streams than it is near the larger ones, and is very similar in texture to that of the uplands, from which it is largely formed by wash. That along the Iowa River is somewhat more sandy in the western part of the area than in the eastern part.

The largest body of Kaskaskia loam occurs along the Iowa River, where a strip about 2 miles wide extends the whole length of the county. It also occupies considerable areas along Salt, Wolf, and Deer creeks. Like nearly all alluvial soils, its surface is very flat and level and is only very rarely broken by a small slough. Near the streams the soil is usually well drained and there is no difficulty in producing crops. Closer to the bluffs, however, many of the areas are nearly always wet until late in the year, and on some of them cultivation is rarely attempted. This is especially true of the land along the Iowa River, where the bottoms are so wide and the land so flat that the water running off from the bluffs or falling as rain finds it difficult to reach an outlet to the river. One or two ditches have been dug in an attempt to drain some of this bottom land and a few levees have been built. Most of the farmers, in discussing the question of draining this land, say that drainage is needed only when the river is up, and at such times the drains are ineffective. However, it seems possible that a system of ditches and levees could be established whereby all the land could be drained. Besides these wet places, a few small ponds are seen, in which the water stands nearly all the year. This is more particularly true of the streams in the northern part of the area. The question of drainage for these and other wet places is worthy of careful study by those who own the land.

The Kaskaskia loam is an alluvial deposit left on the bottoms when the streams overflowed, added to, to some extent, near the hills and on the smaller streams by wash from the surrounding types. As these bottoms were once timbered and were more or less damp, the organic matter was not completely removed by decomposition processes, but accumulated from year to year, which accounts for their present dark color. In places the streams show some tendency to cut deeper into the bottoms and form others lower down, but this has not been done as yet, and the streams are only 10 or 12 feet lower than the surface of the soil.

Corn, oats, and hay are the chief crops of the Kaskaskia loam. Corn yields from 30 to 70 bushels and hay from 1 ton to 2 tons per acre. Oats average from 25 to 50 bushels. During favorable seasons the yields are larger, but the average is cut down by overflows and wet seasons. Practically all the smaller bottoms and a good part of the larger ones are left in pasture, especially where they are inclined to be wet. With proper drainage and diking some of these areas could be cultivated and handsome profits realized from certain crops.

The following table gives mechanical analyses of typical samples of the Kaskaskia loam:

Mechanical analyses of Kaskaskia loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10856	2¼ miles W. of Traer.	Dark-brown silty loam, 0 to 18 inches.	0.2	0.9	0.8	2.8	12.2	67.6	15.6
10876	¼ mile NE. of Longpoint.	Dark-brown silty loam, 0 to 18 inches.	.1	1.2	1.5	4.7	9.9	59.9	22.7
10878	5¼ miles W. of Tama.	Dark-brown silty loam, 0 to 22 inches.	.1	.9	1.7	3.1	10.7	58.7	24.8
10857	Subsoil of 10856	Gray heavy silty loam, 18 to 36 inches.	.3	.9	.8	1.6	9.5	66.0	20.9
10877	Subsoil of 10876	Gray silty clay, 18 to 36 inches.	.2	.7	1.6	6.7	11.6	56.6	22.4
10879	Subsoil of 10878	Gray silty clay, 22 to 36 inches.	.2	1.0	1.8	3.7	9.2	56.7	27.4

MIAMI FINE SAND.

The Miami fine sand is a light-brown or gray loamy fine sand, from 8 to 14 inches deep, underlain by a yellow fine sand of about the same texture as the soil but containing much less organic matter. Sometimes both soil and subsoil are very loose and sandy; at other times, and this is especially true around the edges of areas where the sand grades into other types, it is very loamy and often heavy enough for a light sandy loam. There are one or two places where the soil is loose enough to be blown about by the wind. Here the surface soil is nearly white and organic matter is almost entirely lacking. Most of this type is almost a pure quartz sand, free from either stones or gravel and with very little coarse sand.

The greater part of the Miami fine sand is found on the bluffs and hillsides along the river in the southeastern part of the county. It always occurs in small areas ranging from half a square mile down to 5 acres or less in extent. A few areas are found near streams in other parts of the county. Some are too hilly to cultivate.

The topography of this soil type and its location near streams would give it good natural drainage even were it not for the fact that the texture of the soil permits the ready passage of water through it to such an extent that it does not wash so badly as the Miami silt loam, though the soil is more loose and incoherent. Crops sometimes suffer from lack of moisture.

The Miami fine sand is a wind-blown deposit, which was probably brought down by the waters of the streams at or shortly after the retreat of the Iowan ice and transported to its present place by winds. Some areas are yet blown about by winds. Whenever vegetation gets a foothold and organic matter is incorporated, the soil becomes stationary. This deposit covers the loess, but deposits of a similar nature are occasionally found underneath the loess.

At present the Miami fine sand is planted to the same crops as the other soils of the area. Corn yields from 20 to 40 bushels per acre, oats from 20 to 30 bushels, and other crops in proportion. No hay is produced on this type, but some areas are utilized for pasture with more or less success. This is the only soil type within the county which at all resembles an early truck soil. Watermelons, cantaloupes, early peas, tomatoes, and green corn would thrive upon it. Early Irish potatoes would do well on the more loamy areas. Peaches, plums, and cherries have been grown successfully upon this type at other points. It is quite probable that some of the crops just mentioned would pay better than the grain crops to which this type is at present devoted. Few of such crops, however, are seen within the area, and as there is only a small body of this sandy type it is probable that nearby markets could be found for all the truck produced within the county.

The following table gives mechanical analyses of typical samples of this soil:

Mechanical analyses of Miami fine sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
10868	3 miles N. of Montour.	Gray fine sand, 0 to 12 inches.	0.1	4.2	15.0	49.2	11.2	15.4	4.4
10866	4½ miles NE. of Toledo.	Gray fine sand, 0 to 14 inches.	.3	5.6	21.9	47.6	7.0	10.3	7.4
10869	Subsoil of 10868..	Yellow fine sand, 12 to 36 inches.	.1	3.0	14.8	49.4	11.8	14.2	6.8
10867	Subsoil of 10866..	Yellow fine sand, 14 to 36 inches.	.1	4.1	19.7	50.2	7.9	10.5	7.5

MARSHALL LOAM.

The Marshall loam, to a depth of 10 to 14 inches, is a rather heavy brown loam, similar in color to the Marshall silt loam, but differing from it in containing considerably more fine and coarse sand. This is underlain by a yellow loam, in which particles of coarse sand and

and sometimes by an almost pure sand. It is the most variable soil in the area. Occasionally a few stones are found in the soil, and more often in the subsoil, which is an unchanged glacial till. Farmers speak of this type as being underlain by sand in order to distinguish it from the Marshall silt loam, which they say is underlain by clay. Even where the immediate subsoil is a loam, sand may be found at less than 3 feet.

The greater part of this soil type is found in Howard Township, on the tops or slopes of the scattered morainal hills which are a feature of the topography in that section. It also occurs on slopes near streams in other parts of the county. These slopes are generally rather steep. The type is always found in small, scattered areas, ranging from 5 acres up to half a square mile in extent, and is naturally well drained. It is the only soil in Tama County formed directly from glacial drift, and is developed in places where the loess was deposited as a very thin layer or where it has been washed away. Usually some silty material has become mixed with the drift, which gives the soil the characteristics of a heavy loam. The subsoil is practically unaltered drift.

Where the Marshall loam is cultivated corn and oats are the chief crops. Corn yields from 35 to 50 bushels per acre, and oats slightly less. There is not much difference between the yields on this type and those on the Marshall silt loam, save where the subsoil is very sandy, and these places are used generally for pasture.

The Marshall loam is well adapted to general farming. The hilly spots would make good orchard sites, and the steep slopes should be left in pasture. The more level areas would grow fine Irish potatoes and other vegetables. More attention should be paid to incorporating organic matter with the soil.

The following table gives the mechanical analyses of fine earth of typical samples of the Marshall loam:

Mechanical analyses of Marshall loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10881	3½ miles N. of Toledo.	Brown loam, 0 to 14 inches...	0.4	4.3	5.7	10.3	10.2	44.3	24.6
10882	Subsoil of 10881 ..	Yellow loam, 14 to 36 inches..	1.6	7.6	11.7	22.2	10.3	25.3	21.1

AGRICULTURAL METHODS.

The methods of farming in Tama County do not differ materially from those practiced in other sections of the Middle West. The chief interest centers in the production of corn, which is the main crop throughout the county. Gang and sulky plows, together with some walking plows, are used to prepare the ground for cultivation. Gang plows are used to a much greater extent on the more level lands. The usual practice is to plow as much as possible of the corn land in the fall, as this materially lessens the rush of work the next spring. The land is then prepared with harrows--disk and tooth—and with rollers. The corn is planted in checks and cultivated from three to five times, the small shovel cultivators being more commonly used.

A large part of the corn is cut for fodder, the corn being husked from the shock and the whole stalk fed to the cattle. Corn binders are coming into use. Sometimes the fodder is shredded, and on account of the great number of live stock kept in the county it is likely that this practice will become more common. Oats are generally sown broadcast and disked in. Barley, rye, and wheat are generally sown with drills. All of these grains are cut with self-binders. Part is thrashed out of the shock, while the remainder is stacked in the field. Where one person has two or more of these grain crops he usually stacks some of them, so that all may be thrashed at the same time. Grass is sown in the oats or small grain. Machines operated by horsepower are in common use for stacking hay. Wherever possible, machinery is made to take the place of manual labor.

The rotation best suited to the needs of this area, according to the more progressive farmers, is corn for two years, oats or small grain one year, followed by grass or clover. A great many farmers, however, make no pretense of following this or any other plan of rotation and grow corn and oats for many years on the same land. Comparatively little clover is grown. In 1900, out of a total of over 390,000 acres in the county in crops, only 1,300 acres were in clover. Very little difficulty is experienced in getting a stand of clover, though there is some danger of damage by freezing. The introduction of more leguminous crops into the rotation would no doubt be beneficial to the land, even to the dark prairie soils. Alfalfa has been grown successfully on the Marshall silt loam, and probably can be grown on most of the other soils in the county, except in the damp places on the bottoms. Rape is also grown to some extent as pasture for sheep and hogs, and seems to do well.

A large quantity of manure is produced within the county. Much of it finally reaches the fields, but as it is first thrown out under the eaves, on hillsides, and in other places where it is exposed to the weather, a considerable part of its original value is lost. Machine spreaders are in use, but some of the manure is spread by hand. Some of the straw produced on the farms is fed to stock and used for bedding purposes, but a great deal of it is burned. Not very much attention is paid to turning under green crops for manure. The proper use of these crops and the incorporation of organic matter with the soil should be given more attention by the farmers. This is especially true with regard to the Miami silt loam and the Miami fine sand, and even with the Marshall silt loam the humus in the soil should be maintained if the best results are to be expected.

The importance of housing farm machinery and implements is not fully appreciated in Tama County. It is a very common sight to see self-binders and other valuable machines standing out all winter in the fields where they were last used. The manufacturers, taking this fact into consideration, regard the average working life of a binder as not much over thirty days of actual service, which would make its value about $4 a day when used. Housing and caring for these machines would at least double their working life, and it would seem to be a profitable investment to build sheds for them.

Tile drains for the marshy places and drains in the Marshall silt loam would be a step forward. The hills of the Miami silt loam should be seeded down to permanent pastures, and broken up only at long intervals, if at all. If a good grade of stock is kept and pastured on these places, about as profitable returns can be secured as in any other way, and the danger from washing will be removed, while, at the same time, the land will increase in productiveness. When these lands are cultivated, the rows should be made to follow the topography, and terraces should be built at intervals.

AGRICULTURAL CONDITIONS.

Over the greater part of the area occupied by the Marshall silt loam the general appearance of the farm buildings and their surroundings indicates a highly prosperous agricultural community. The average value of buildings on farms, according to the Twelfth Census, is $1,500, but houses alone costing from $3,000 to $10,000, and even more, are not uncommon. On rented land the buildings are not so good and bring down the average value. Where the owners live on their farms few residences of less value than $2,000 are seen. Both residences and barns are usually painted, many looking as if they had been built quite recently. As a rule, the buildings are not quite so good on the areas occupied by the Miami silt loam, but there are many beautiful residences among the hills. Only a few farmers live on the Kaskaskia loam.

Those who came here when the county was first settled have made small fortunes from farming and the rise in land values. Many have retired from active work, having leased or rented their farms, and now live in the towns.

Practically every foot of the Marshall silt loam can be used for growing crops, and there is no land in the county which can not be utilized for some agricultural purpose. The best lands, when near the towns, can not be bought for much less than $100 an acre. In less desirable localities the price ranges from $70 to $90 an acre. Land on the Miami silt loam and the Kaskaskia loam can be bought for from $50 to $75 an acre. In the last few years, owing to excessive rainfall during the growing seasons, the crop yields have been materially lessened.

Comparatively few farms are mortgaged. Rural telephones are much in use. Cooperative lines, owned by the farmers, are noticed on almost every road, and few farmers in the county are without telephone service. As an investment the farms of Tama County pay a rather low rate of interest unless operated by the owners themselves, because the rent is disproportionately small as compared with the value of the land. Slightly over one-half of the farms are operated by the owners, the remainder being in the hands of tenants, who pay a rental of from $3 to $4.50 an acre, varying with the quality of the land, the improvements, and the distance from markets. A few are operated for a grain rent of from two-fifths to one-half of the total amount produced, according to the amount of seed furnished by each party. The cash-rent system is most common, and in some sections is almost universal.

The average size of farms in Tama County is 161 acres. Quarter-section farms are the general rule, but farms ranging in size from 80 to 640 acres are also seen. Many landholders own as much as 4,000 or 5,000 acres, but these large holdings are always rented out in smaller tracts, usually in quarter sections. The difficulty of securing labor has had some tendency to restrict the size of farms, but this has been offset to some extent by seeding down to grass.

The labor in the area is exclusively white and is secured mainly from among those who were born and reared here, though some Bohemians and Germans are employed. The wages vary from $20 to $30 a month, almost anyone being able to get $20 a month and board, besides the maintenance of a horse. As far as possible the farm work is done by machinery. There is a demand, therefore, for skilled laborers who can handle gang plows, self-binders, four-horse teams, etc., and anyone who can do this seldom has any trouble in securing employment at the higher rates of wages. Most of the labor employed is efficient. At times there is a scarcity of labor, and many farmers have been compelled to seed down their farms because they were unable to obtain sufficient help to cultivate them. As a rule, hands are employed from seven to nine months in the year, and where a considerable amount of stock is kept they are hired for the whole year. On the smaller farms day laborers are occasionally desired. According to the Twelfth Census, the average expenditure for labor per farm is $85 a year. As this would only pay the wages of one man for three or four months, and as hands are hired for about twice that length of time, it would seem that on about half the farms in the county all the labor is performed by the farmer and his family.

Corn is the principal product of this area. In the year 1899, according to the last census, over 28 per cent of the land in the entire county, or 33 per cent of the improved land, was planted to this crop, which produced 5,341,740 bushels, or an average of 41.6 bushels per acre. Oats are second in importance, occupying from 10 to 15 per cent of the land. The average yield for the entire county is about 35 bushels per acre. Barley and wheat are also crops of some consequence, and a considerable quantity of hay of various kinds is grown. Comparatively little clover is grown. Bluegrass is used almost universally for pasture in the uplands, and it soon forms a dense sod.

Very little fruit of any kind is seen. It is said that several years ago apples and pears were produced in sufficient quantities for home use, but the old orchards have died out and few new ones have been planted. It would seem that more attention should be given to orcharding, especially in the hilly sections. The winters are so severe, however, that only the hardy varieties should be cultivated. Some small fruits, such as strawberries and raspberries, are grown for the local markets in the vicinity of Garwin and at some other points.

Aside from the products obtained directly from the soil, one of the most important industries of Tama County is the raising of live stock, which consists chiefly of cattle and hogs, with a few horses and some sheep. The cattle are mainly of the beef breeds, the Herefords predominating in the southern and the Shorthorns in the northern section of the county, with a few Angus at various places in the area. Very little attention is given to dairying, although there are a few creameries in the area. Most of the hay, grain, and fodder produced in the county is consumed within its limits, being fed largely to the cattle and hogs. Some of the more progressive farmers even buy corn from their neighbors to feed to their stock. The value of the live stock in the county in 1900 was $3,895,000, or $1,425 per farm. A few stock farms of some reputation are found within the area, though it can not be said that the raising of pure-bred live stock has attained much importance as yet. Most of the animals are of a fair grade and many farmers use registered males.

The Marshall silt loam is recognized as being well adapted to corn, oats, and hay and is cultivated to these crops. About the same proportion of the Miami silt loam is planted to the above-named crops.

Some farmers say that the Miami silt loam withstands dry weather as well as the Marshall silt loam and that its topography prevents it from becoming too wet for crops during rainy seasons; hence they prefer it. The danger of damage from washing, however, is much greater on the Miami silt loam. Almost all the bottoms are planted to corn, oats, and hay, except where drainage is needed, and there they are left in pasture. It would be hard to find soils better adapted to general farming than these two types, especially the Marshall silt loam. Tile drainage of the draws and sloughs would, of course, greatly increase the yields of cultivated crops. Strawberries and other small fruits have been grown on the tops of hills and ridges in the Miami silt loam, it being generally recognized that there is less danger of frost on the hills than on the level lands. For the same reason these hills are suited to apples, pears, etc., as the soil is naturally adapted to those crops. Owing to the great danger of damage from washing, all the steep slopes and gullies of this type should be seeded down to grass and left in pasture. Good returns from the land can be secured in that way.

The Kaskaskia loam is well adapted to corn and oats, but a great deal of it would yield larger returns if diked and drained. The Miami fine sand is usually planted to the same crops as the other soils. It is best adapted, however, to watermelons, cantaloupes, and other truck crops, and in the more loamy places to potatoes. The extent of this sandy type in the area is so small that everything produced upon it ought to find a ready market within the county. The possibilities of this soil for truck crops are not yet fully appreciated by the farmers in the area.

Good dirt roads are found on nearly every section line throughout the more level portions of the county. In the hills some attempts have been made to follow the topography, but in many instances the roads go straight down the land lines and up and down hills in such a manner as to render the hauling of heavy loads very difficult. These roads are all made by simply grading up the dirt, clay, etc., which is at hand, there being scarcely any rock or gravel which could be utilized as a road-surfacing material. During the winter and early spring the roads, more particularly on the level prairie and the bottoms, sometimes become almost impassable for heavy hauling. In Indian Village and South townships there are quantities of limestone, which, if crushed, would make a fine roadbed, but this is not utilized at present, even in the immediate vicinity of the quarries. The main roads are graded up again every spring, and when once dry are good throughout the summer.

Branches of four railway systems touch Tama County. The main lines of both the Chicago and Northwestern and the Chicago, Milwaukee and St. Paul railways, from Chicago to Omaha, pass through the southern part of the county. From Tama and Belle Plaine branches of the Chicago and Northwestern extend northward across the eastern and western sections of the county, respectively. The Chicago, Rock Island and Pacific Railroad crosses the northeast corner of the county and the Chicago and Great Western Railroad the northwest corner. This leaves a large area in the center of the county untouched by any railroad, and many farmers in that section have to drive 8 or 9 miles to reach a shipping point.

Tama and Toledo are the largest towns within the area. Tama has a population of about 2,800, while Toledo has about 2,300. Chicago is the great market for the products of this county. Grain elevators are found at nearly all the small towns and stations along the railroads. Live stock is loaded on the cars and shipped direct to Chicago. The transportation charges are of course high—the distance is 270 miles—and reduce somewhat the profits of the farmers.

SOIL SURVEY OF SALINE COUNTY, MISSOURI.

By M. EARL CARR and H. L. BELDEN.

LOCATION AND BOUNDARIES OF THE AREA.

Saline County is located in the west-central part of Missouri, in a broad northward bend of the Missouri River, about two-thirds of the way from St. Louis to Kansas City. Pettis County forms its entire southern boundary and Lafayette County the western, while Cooper County lies on the southeast. The Missouri River forms the northern boundary and also the eastern for a distance of nearly 75 miles, and separates Saline from Carroll, Chariton, and Howard counties.

The county lies between 38° 52′ and 39° 20′ north latitude and 15° 55′ and 16° 30′ west longitude from Washington. The greatest distance across the county from north to south is 31 miles, and from east to west, 33 miles, and the area covered is about 748 square miles, or 478,656 acres.

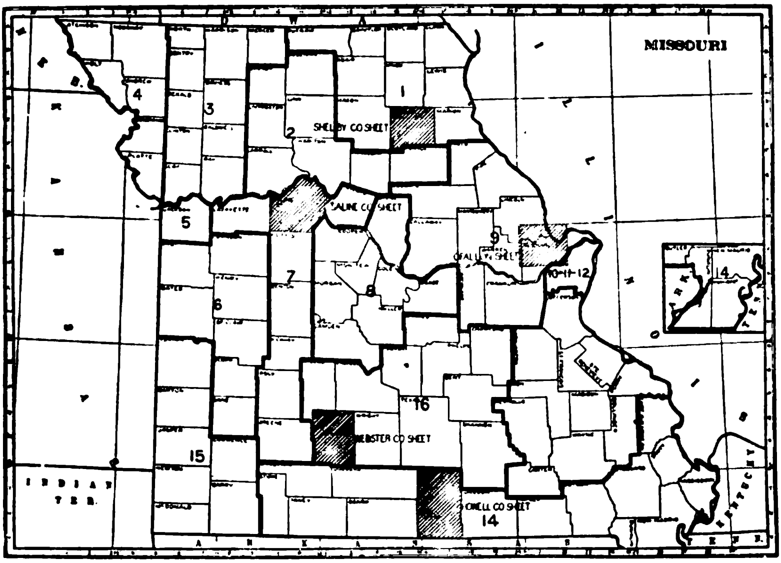

FIG. 33.—Sketch map showing location of the Saline County area, Missouri.

The base map used was made up of United States Geological Survey sheets, revised as to roads and some other minor details by the party in the field.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The first authentic record of the presence of white men in that part of Missouri now included in Saline County dates from 1806, when the Lewis and Clark expedition passed through the country on their return from exploring the source of the Missouri River. In 1807 Capt. George Sibley established a trading post on the river where Arrowrock now stands, which was maintained until the breaking out of the war of 1812, when it was abandoned. The first real settlement was made in 1810 by Jesse Cox, a Kentuckian by birth, on the bottoms above Arrowrock. The following year he moved his family to his newly built cabin, being accompanied by his son-in-law, William Gregg. They were joined in 1813 by Frank and William Cooper. During the war of 1812 the Indians were numerous and annoying, and Christmas week, 1814, the settlement was attacked and Gregg killed. Cox then went to the fort across the river with his family, where they remained until the close of the war, when they again returned to their home west of the river. No other settlements were attempted until June, 1816, when Daniel Thornton and Isaac and William Clark, of Tennessee, moved to Cox's bottoms with their families. Thornton was a native of North Carolina. In November of the same year five other families joined the settlement. By 1820 several hundred people had come, mostly from Kentucky, Tennessee, Virginia, and Indiana, and lived in settlements for protection against the troublesome Indians. At a later date a number of Germans located in the county, and their descendants now constitute a considerable proportion of the population of the county.

Saline County was formed from a part of Cooper County, and organized by an act of the first State legislature, approved November 25, 1820, taking its name from the numerous salt springs within its borders. It then contained a much larger area than at present. In 1825 the legislature established the present boundaries. The act of organization fixed the county seat at Jefferson, where it remained until 1831, when it was removed to Jonesboro, now Napton, where it remained for eight years. It was then located temporarily at Arrowrock for about two years, and when the courthouse at Marshall was completed that town became the permanent county seat, the name of the town being in honor of John Marshall, Chief Justice of the United States. The first census of the county, taken in 1821, showed a population of 1,176.

The earliest settlers subsisted largely by hunting, and depended but little on the outside world, even for clothing; enough corn and vegetables being grown for their own use. An orchard was planted in 1817 with seed brought by one of the early settlers from Tennessee. A notable event in the agricultural development of the county occurred during the season of 1819. Two settlers experimented by planting 3 pecks of wheat on the open prairie, and a yield of 20 bushels demonstrated, contrary to the belief of the settlers, that the unwooded plains would produce as good crops as the timbered strips along the streams. It is a singular fact that the early settlers always located on the timbered land instead of on the rich prairie, which covered about 80 per cent of the county.

The first export from the county consisted of a quantity of bacon, which was floated down the river in the fall of 1820. About this time steamboats began to make regular trips up and down the river and the exportation of farm products steadily increased. By 1824 farms had become quite numerous, and thriving towns had sprung up on the river which had frequent communication by steamer with St. Louis. The advantages afforded by a water route to the East made possible the early and rapid development of this rich region, so that by 1840, nearly forty years before railroad connections were established, it had become quite thickly settled. The early settlers found the prairie and valley grasses growing in great luxuriance. Until 1840 these wild grasses, used for grazing, were one of the principal resources, and even much later they were used to a considerable extent for both hay and pasturage. Finally they were entirely superseded by the domestic varieties, as timothy was found to excel and red clover to do as well as in the Eastern States. Up to about 1870 the success of bluegrass on the prairie was doubted, but later it became the leading pasture grass and is now as common as its companion, white clover.

The acreage in corn has at all times been much larger than that of any other crop, and from 1840 to 1850 it was about four times that given to wheat, which was second in importance. During this decade the production of these two crops and of oats and hay doubled, as did also the number of cattle and sheep raised, while the number of swine raised increased twelvefold. Thousands of tons of hemp were grown annually from 1850 to 1860 and even later, but the importation of jute and other foreign fibers made this industry unprofitable. The increase in the production of corn exceeded that of all other crops, and by 1860 it was by far the most important article of export.

The civil war, together with the changed conditions resulting therefrom, acted as a severe check to the prosperity of the farmers and to the county generally. However, by 1870 the value of farm products greatly exceeded that of 1860. This phenomenal development following the civil war is remarkable, when it is considered that no railroad transportation was afforded for the products, except in the extreme southwestern corner of the county, until 1878, when the Chicago and Alton Railway was completed to Marshall. A few years earlier a branch of the Missouri Pacific Railway was built from Sedalia to Lexington, touching the county at Sweetsprings. This was followed in 1887 by the building of the river route of the Missouri Pacific through the county. During the decade from 1860 to 1870 wheat had gained most rapidly, its acreage becoming more than half that of corn. This increased production of wheat continued about twenty years, when its low price and the increasing price of corn and beef turned the farmers' attention more strongly than ever before to these industries, to which the soils, climate, and transportation facilities of the county are so well adapted.

CLIMATE.

The following table, compiled from the records of the Weather Bureau, gives the normal monthly and annual temperature and precipitation for Marshall and Miami. The figures for the former place are computed from records for the last fourteen years, while those for Miami cover twenty years for temperature and fifty-five years for precipitation.

It will be seen that the greatest rainfall occurs during the growing season—May, June, and July—and that ordinarily it is sufficient, but not excessive, during the harvesting period.

The winters are not particularly severe, although extremely cold weather is not uncommon, temperatures of zero and below being often reached. The summers are generally equable, and when high temperatures are reached the heat is almost always tempered by the prairie breezes.

For the season of 1903, the last killing frost in spring occurred May 1, and the first in the fall on October 18. These dates probably represent fairly well the length of the growing season, 170 days, in which immunity from frost may be expected. This gives ample time for the growing and maturing of all the staple crops grown in the county.

Normal monthly and annual temperature and precipitation.

Month.	Miami.		Marshall.		Month.	Miami.		Marshall.	
	Temperature.	Precipitation.	Temperature.	Precipitation.		Temperature.	Precipitation.	Temperature.	Precipitation.
	° F.	*Inches.*	*° F.*	*Inches.*		*° F.*	*Inches.*	*° F.*	*Inches.*
January	26.3	1.59	28.3	....	August	75.7	3.76	75.9	3.78
February	28.8	1.82	27.5	2.02	September	68.1	3.41	68.1	3.41
March	41.4	2.48	40.6	3.00	October	57.0	2.97	56.5	2.21
April	55.9	3.07	54.7	3.43	November	42.4	2.08	41.8	1.98
May	65.7	4.23	64.8	4.94	December	32.2	1.94	30.6	1.91
June	73.6	4.82	72.8	4.32	Year	53.8	36.34	53.2	....
July	78.3	4.17	76.9	4.24					

PHYSIOGRAPHY AND GEOLOGY.

The relief features of the county consist of two natural physiographic divisions—the lowlands or "bottoms" along the Missouri River and the prairie or uplands. The latter is by far the most important, both in size and agricultural interests, as on it are located some of the finest farms to be found in the State, if not in the whole country. It extends over the entire southern and central parts of the county, and also touches the river at several points on the north and east, notably at Miami, New Frankfort, Cambridge, Saline, and Arrowrock. This upland division consists of two parts—the prairie proper and the wooded areas—and the topography is generally that of a high, rolling, well-drained section. The general character of the prairie portion proper is nearly level to rolling with steep slopes to the streams.

A prominent exception to these rolling uplands is the Petesaw Plains in the northwestern part of the county, which have an elevation of about 750 feet and extend from west of Maltabend to Muddy Creek on the east, and north from Salt Fork Creek to the bluff separating them from the bottoms, which are about 50 feet lower.

The soils of these prairies are well watered and drained, except some few fields, where an impervious subsoil lies so near the surface that it prevents the meteoric waters from quickly passing below the point at which they are injurious to growing crops. Underdrainage for these areas would eliminate this difficulty.

The wooded areas are mostly in the southern part of the county and along some of the streams. The topography of this subdivision of the uplands is not so uniform as that of the prairies. Precipitous slopes and sometimes vertical cliffs occur, giving the country a rugged appearance. In many places erosion is quite pronounced, giving rise to rough topography. In some of these places glacial drift buried underneath the loess is exposed, the most marked examples of this erosion being along Salt Fork Creek, east of Marshall, and the rough country along the river bluffs.

The soils of this division are generally characterized by heavier subsoils. In many places the bed rock comes to the surface in gullies and on slopes, adding to the general irregularity of the surface.

The topography of the river lowlands or bottoms, as they are called, is that of a nearly level plain, extending from the bluff to the river bank. As a rule these bottoms are lower at the bluff than near the river, and sometimes the surface is broken by a low swell or a depression, marking an old water course. The sandy areas are usually distinguished from the heavier ones by a slightly irregular surface. There are five separate bodies of these bottoms, the most important one, which is larger than the other four combined, being in Grand Pass Township, in the northwestern part of the county. In this bottom there are several low swampy places, old lake beds, which have been partially drained by cutting channels from them to the river. They undoubtedly are remnants of old river channels abandoned many years ago. These bottoms are about 12 to 15 feet above the ordinary level of the river and are subject to occasional overflow. The soils are liable to change with each overflow, according as sandy or heavy material is deposited.

The river is constantly changing its course, building up land here and washing it away there, a notable instance being the undermining and washing away of Laynesville during the high waters of 1903.

There are three systems of drainage in the county. The largest stream is Blackwater River, which enters the county near the southwestern corner and flows, in a tortuous course, in an easterly direction. It receives numerous tributaries, the largest of which, in the southern part of the area, are Davis and Finnis creeks. It drains the entire southern part of the county and passes into Cooper County, near Nelson. Salt Fork Creek, a still larger tributary, is the most important stream, draining, as it does, the large part of the county. It rises in Lafayette County and enters Saline County in Grand Pass Township, then flows easterly to the vicinity of Blosser, where it takes a southeasterly course and joins Blackwater River just above Nelson. Its main tributaries are Pass and Salt branches and Straddle Creek from the south, and Muddy, Cow, Rock, and Camp creeks from the northeast. The bottoms are drained by the small streams which empty into the river, the largest of which are Edmonson, Bear, and Fish creeks. Flat Creek, another small stream, having its source west of Saline, flows south and east into Cooper County.

Lying as it does near the southern limit of glacial action, the surface features of the county are both glaciated and unglaciated. The geology of this part of the State has never been thoroughly worked out, but from an agricultural standpoint it is important in that some of the soils are residual in origin and depend upon the nature of the rocks from which they are derived. The whole basal structure belongs to the Paleozoic age of geological time. An irregular shaped area in the western part of the county and also some smaller irregular areas northeast of Salt Fork are underlain by siliceous limestones and sandstones of the Lower Carboniferous period. The remainder of the county, except two small areas, belongs to the Coal Measures. The two exceptions just mentioned are limestones belonging to the Devonian period, one of them occurring along Blackwater River in the southeastern part of the county, and the other just north of Saline. All of these formations furnish building stone and an excellent road metal. In the Coal Measures are numerous thin furnishing a cheap fuel for local use. They are too thin to work on a commercial scale. In the southeastern part of the county there are pockets of cannel coal said to be of an excellent quality.

In the southern part of the county are quite extensive areas which have not been modified by the deposition of glacial material. The Quaternary period is represented by the glacial material and the more recent deposits of alluvium, as represented in the river bottoms and along some of the streams. A large portion of the county is covered up by a mixture of sand, silt, and clay of varying depths, termed "loess" by geologists. This loess is supposed to be wind-blown material deposited in shallow water about the close of the Glacial period. In the vicinity of Marshall there is distinct evidence of glacial drift underneath this loess.

SOILS.

The soils of Saline County, according to their physiographic features, fall into two natural divisions, the bottom soils and the upland soils. Considering their derivation the upland soils are divided into glacial or loessial and residual soils. These relations are shown in the following table:

Soils of Saline County	Bottom (Alluvial)		Yazoo clay. Yazoo loam. Clarksville loam. Meadow.
	Upland	Loessial	Marshall silt loam. Miami silt loam.
		Residual	Clarksville silt loam. Clarksville stony loam.

As seen in this table eight types of soil, including Meadow, were recognized in the county. The following table gives the actual and the relative area of each of these types:

Area of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Marshall silt loam	306,816	64.6	Clarksville stony loam	7,296	1.4
Clarksville silt loam	67,520	14.1	Clarksville loam	5,440	1.1
Miami silt loam	43,776	9.2	Meadow	3,584	.7
Yazoo clay	28,544	5.9	Total	478,656	
Yazoo loam	15,680	3.0			

MARSHALL SILT LOAM.

To a depth of 15 to 20 inches the soil of the Marshall silt loam is a black, or, less frequently, a dark-brown, mellow silt loam. When changes to an ashy gray. The subsoil is usually a heavy silt loam, brown or brownish black in color, sometimes becoming mottled with brown, yellow, gray, and black at from 24 to 30 inches below the surface. The deep subsoil is much lighter in color, being usually a gray silty clay. One phase of this soil has an impervious subsoil occurring near enough to the surface to make local areas wet. These areas are known as "hardpan" soils by the farmers of the county. Another phase occurs along some of the streams and in hollows, where the soil is much deeper, having been added to by washings from the neighboring slopes.

The Marshall silt loam is by far the most extensive soil type in the county, covering about 65 per cent of the total area. It occurs in an extensive body over the entire central portion of the county, except where broken by relatively small areas of Miami silt loam, Yazoo clay, and Meadow, mainly along Salt Fork Creek. The large area extends to the Cooper County boundary on the southeast, to the rough, broken country on the east and north, and borders Lafayette County from 4 miles south of Blackburn northward to the bluffs which separate it from the river bottoms. Several smaller isolated areas occur in the southern part of the county, the largest being in the vicinity of Sweetsprings.

The topography of the type as a whole is gently rolling. Along some of the streams it becomes quite hilly, and on the other hand there are areas nearly level or only slightly undulating. Some of the hilly portions have a thinner soil, and the more level areas a much deeper soil than does the general type. It is usually these thinner soils that have the brown color, indicating a less amount of organic matter. The most notable of these level areas is the Petesaw Plains, in Grand Pass Township. These plains, although nearly level, are pretty well drained, a few open and tile drains being maintained. An extension of these tile drains would insure more satisfactory crops for some fields in wet seasons.

The high, rolling portion of the Marshall silt loam is well supplied with small streams, which serve to carry off quickly any excess of surface water. Though well drained, the texture of this soil is such that the soil moisture is conserved and crops do not suffer except in case of long-continued drought. As stated elsewhere in this report, the hardpan areas would be greatly benefited by the installation of tile underdrainage.

The wide distribution and uniformity of the Marshall silt loam as it is found in this county is explained by the consideration of its origin and process of formation. The material of which it is composed is a mixture of sands, silt, and clay known as loess. Many theories have been advanced explaining the method of deposition of this mantle of loess. Some attribute its presence to æolian agencies alone, while others are equally certain that it is both æolian and aqueous—that is, a wind-blown material deposited in a shallow inland sea, which they suppose was formed by the melting of the ice at the close of the Glacial epoch. The latter theory is probably the most acceptable, as some of the characteristics of the deposit can not be satisfactorily explained otherwise. Disregarding the theories of origin and deposition, none can dispute the natural productiveness of the soils derived from it, and the Marshall silt loam is no exception, unless we say exceptionally productive. The black color of the soil is due to the accumulation of organic matter, which aids in securing a good tilth and helps to conserve the soil moisture for the growing crops.

As one would expect of a rich soil like this, the yields of corn, wheat, and hay—the money-making crops—are large, and fruits, garden vegetables, etc., for home use are plentiful. Indian corn, the chief product of the county, is extensively planted on this soil and yields from 30 to 100 bushels of shelled corn to the acre, the average probably being about 45 bushels. In 1875 a prize of $200 was offered for the best 10 acres of corn raised in the county that season. About 20 pieces were planted to compete for this prize, each of which yielded more than 100 bushels per acre. The prize 10 acres was grown on the Marshall silt loam, where a part of the village of Maltabend now stands, yielding a few pounds more than 124 bushels per acre. Wheat yields from 12 to 25 bushels, averaging about 18 bushels. Some yields of wheat as high as 40 to 45 bushels have been secured, but these large yields were not common even on the soils before they had been continuously cropped. One great difficulty encountered in growing vegetables and garden truck is the rapid and abundant growth of weeds. It requires much care and labor to keep these troublesome plants from choking out and killing the crops. However, when careful and frequent cultivation is practiced large crops are produced. Some fruits for home consumption are grown. Numerous apple orchards are located on this soil, but none of any great size. The trees grow very rapidly and are not generally well shaped. The extension of these orchards can not be recommended, as the trees grow very rapidly and reach maturity so soon that they are not very long lived and do not bear so well as orchards planted on less productive soils.

On nearly every farm the stock are supplied with water from ponds, made by constructing a dam across some small ravine, which holds either the surface water or water from some near-by spring.

The following table shows the results of mechanical analyses of typical samples of the Marshall silt loam:

Mechanical analyses of Marshall silt loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12358	2 miles W. of Marshall.	Black silty loam, 0 to 15 inches.	0.1	0.6	0.4	1.9	7.6	71.0	17.8
12356	1½ miles E. of Maltabend.	Black silty loam, 0 to 16 inches.	.1	.4	.2	.6	8.8	71.9	18.1
12360	1 mile S. of Slater...	Black silty loam, 0 to 15 inches.	.1	.3	.2	.9	10.1	69.2	19.1
12357	Subsoil of 12356......	Heavy silty loam, 16 to 36 inches.	.1	.3	.3	1.2	9.0	70.5	18.5
12359	Subsoil of 12358......	Heavy silty loam, 15 to 36 inches.	.1	1.2	.8	1.3	11.6	63.2	21.7
12361	Subsoil of 12360......	Brown silty loam, 15 to 36 inches.	.0	.4	.3	1.2	6.5	69.7	21.9

YAZOO CLAY.

The Yazoo clay is a bottom soil and is known locally as "gumbo." The surface soil, from 10 to 15 inches in depth, is a heavy silty clay loam or clay, black or dark brown in color. The subsoil has very much the same texture as the soil, but is more compact and plastic. It is usually a little lighter in color than the soil, but sometimes it is mottled gray, brown, and yellow or a light drab. The surface upon drying cracks open, but does not dry out to any great depth. When wet the soil is very sticky and exceedingly difficult to till. If plowed and worked at the right time a good tilth can be secured, but if care is not taken to plow when the conditions are very favorable it breaks up into great clods, which interfere greatly with subsequent cultivation.

North of Grand Pass occurs a phase of the Yazoo clay that has a sandy subsoil at depths varying from 12 to 24 inches. This light subsoil is usually far enough below the surface not to have any marked influence on the surface conditions. Sometimes both soil and subsoil are modified with sandy material, but these areas are of no great extent. Much of this type in the river bottoms is heavier and more plastic than that found along the smaller streams in the interior of the county. The most extensive areas of the Yazoo clay are found in Miami and Grand Pass townships, also in the bottom above Saline. Other bodies of it occur along Salt Fork Creek and some of its tributaries, along Davis Creek, near Sweetsprings, and along Blackwater River.

The physiographic position of the Yazoo clay is most unfavorable for drainage. Lying as it does in the flood plain of the river or smaller streams, it is nearly level and subject to frequent overflow. The areas in the river bottoms, although probably not inundated as often, are sometimes entirely changed by the deposition of sandy material. The drainage of this type is very deficient. There is practically no underdrainage, owing to the compact, impervious structure of the soil and subsoil. Open ditches seem to be the only feasible method of draining this soil.

The washings from higher levels and deposition of material carried in suspension in quiet waters accounts for the formation of the Yazoo clay. As only silt and clay are held in suspension where the motion of water is slow, this explains why 95 per cent of the material of which it is composed is of the finer grades.

In Grand Pass and Miami townships in the river bottoms there are remnants of old lakes, which were probably formed by the river leaving its old channel. These areas are covered by shallow water, and around the edges reeds and other water-loving grasses grow luxuriantly. Until a few years ago, when they were partially drained by cutting channels from them to the river, these lakes were very much more extensive than they are now. Since these channels have been cut fine crops of corn and wheat have been grown in favorable seasons.

The drainage of these areas is entirely feasible, and the ditches already cut should be deepened and extended and new ones opened in a few places. An effort was made to have a channel opened along the bluff to receive the water from the springs which occur at the base of the bluff, as well as the surface water which collects on the lower land next to the bluffs, but some of the property owners prevented its being carried out. Such a ditch as this would aid in the drainage of these swamps, as well as benefit all of the land lying along the bluffs. The partial drainage of the old lake beds of the bottoms has already added to the extent of the Yazoo clay, and the further reclamation of these areas will increase it still more.

Dense forests of cottonwood, sycamore, and elm once covered the higher parts of the type, but practically all the timber has been removed and nearly all the area except the lower wet portions has been brought under cultivation. Corn and wheat are the principal crops grown, and in favorable seasons especially large yields are obtained. Wheat seems to do much better on this heavy soil than on the lighter upland soils. Owing to the liability of overflow and consequent uncertainty of obtaining a crop every season, together with the difficulty of cultivation, these lands are not as desirable as the upland soils, and therefore bring much lower prices. In favorable seasons corn yields from 35 to 50 bushels and wheat from 15 to 30 bushels per acre.

The following table shows the results of mechanical analyses of both soil and subsoil of this type:

Mechanical analyses of Yazoo clay.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11879	9 miles S. of Marshall	Black clay loam, 0 to 12 inches.	0.4	0.9	0.4	2.4	1.2	62.5	32.1
11881	2 miles NW. of Maltabend.	Black clay, 0 to 12 inches.	.0	.4	.7	3.0	4.2	49.6	42.1
11880	Subsoil of 11879	Black clay loam, 12 to 36 inches.	Tr.	.6	.4	1.4	.4	68.1	29.3
11882	Subsoil of 11881	Brown clay loam, 12 to 36 inches.	.0	.1	.3	5.1	11.8	50.9	31.3

YAZOO LOAM.

The Yazoo loam consists of from 10 to 14 inches of a dark-brown or gray fine sandy loam or loam, underlain by a gray or brown fine to very fine sand, both soil and subsoil containing a high percentage of silt. The subsoil grows lighter with increase in depth. In many small areas the subsoil is a light sandy loam, and in other places both soil and subsoil are made up of alternate layers of sand, sandy loam, and heavy material. These materials, however, are not arranged in any regular order. A light phase of this type occurs on Whites Island and the mainland lying next to it. Here the loam soil covering is absent and the soil becomes a light gray fine sand 3 feet or more in depth. A lighter phase is also found on the bottom above Arrowrock.

The Yazoo loam is strictly a lowland type and is found in the bottoms along the Missouri River, the largest areas being the bottoms above Arrowrock and in the vicinity of Whites Island. It occurs generally at slightly higher levels than the Yazoo clay, which is associated with it, and consequently has better drainage. Although the surface is not level, the general topography is that of a level plain. The light porous character of the subsoil gives adequate drainage by seepage and none of the water is removed by streams.

Droughts have a more marked effect on crops growing on this type than on those growing on the Yazoo clay.

Like the other bottom soils, the Yazoo loam is subject to inundation by the overflow of the river, and to this fact its origin is due. When the river is high and the bottoms are covered with water, naturally there are swifter currents in some places than in others, and where these swift currents exist sand is deposited, the finer materials, silt and clay, being carried along in suspension and dropped in quieter water, forming the Yazoo clay. As the floods subside and the water moves less rapidly, some of the finer sediments are dropped with the sand, resulting in the loam covering overlying the sand.

Corn and wheat are the principal crops grown on this soil, but the yields do not equal those obtained on the heavier bottom type, the Yazoo clay. The yields are uncertain, as floods sometimes destroy or damage the crops. Melons have been grown on this soil with excellent results, but at present none are grown. In favorable seasons this would make an ideal soil for the production of both muskmelons and watermelons, and if the industry were once established on a firm basis, would, together with the production of other truck crops, prove much more profitable than the growing of corn and wheat.

The following table gives the results of mechanical analyses of typical samples of this soil:

Mechanical analyses of Yazoo loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12352	6 miles NE. of Malta bend.	Silty loam, 0 to 12 inches.	0.0	0.8	0.8	3.7	16.5	69.3	9.6
12350	4½ miles NE. of Miami.	Loam, 0 to 12 inches	.1	.8	.6	16.6	19.9	49.7	12.5
12353	Subsoil of 12352	Silt and very fine sand, 12 to 36 inches.	0	.1	.2	2.3	13.9	78.3	5.0
12351	Subsoil of 12350	Gray fine sandy loam, 12 to 36 inches.	.0	.3	.8	45.3	17.2	30.5	6.1

MIAMI SILT LOAM.

The Miami silt loam is distinguished from the Marshall silt loam chiefly by its color and topography, rather than by any wide variation in texture or derivation. The surface soil, ranging from 6 to

10 inches in depth, consists of a light-brown or gray silt loam. When dry it is rather loose and incoherent, but when wet it becomes sticky and plastic. The subsoil is a heavy silt loam. Its color is a deep brown, and its structure gives it the appearance of a heavy clay. If dry, this subsoil breaks up into angular blocks about an eighth of an inch across. This structure is only seen in the areas in the eastern parts of the county. Like the soil, this subsoil is sticky and plastic when wet.

The widest extent of the Miami silt loam is found in Clay and Cambridge townships. There is a strip of this soil extending along the bluffs from the Cooper County line to a point about 5 miles southwest of Miami. Through Miami Township this strip is narrow, but just before passing into Cambridge Township it suddenly widens out to a width of about 2 miles and gradually widens to about 3½ miles just before reaching the Chicago and Alton Railroad tracks. Beyond this point it abruptly narrows to about one-half mile, becoming still narrower as it passes southward past Saline and Arrowrock. Along the bluffs in Grand Pass Township it is not very extensively developed, but occurs as a narrow strip widening out at and west of Grand Pass. Isolated areas occur in the Marshall silt loam along Rock and Salt Fork creeks east of Marshall and also on Cow Creek and Thrailkill Branch.

The physiographic features of the Miami silt loam are very striking and in sharp contrast to those of the Marshall silt loam. The surface is extremely rolling and hilly. Deep ravines have been cut by the streams, and in many places the bed rock has been exposed, although nowhere are the exposures of sufficient size to be shown on the soil map. A phase having a heavier subsoil occurs on some of these hillsides, due to residual material. Wet areas are rarely found, as the rough topography usually favors good natural drainage.

Like the Marshall silt loam, it is a loess deposit and has developed from the prairie by the processes of erosion. That part of the Miami silt loam lying east of Marshall is interesting from the fact that here the erosive agencies have exposed in many places the glacial drift, which consists of pockets of cherty gravel, sands, clay, etc. In some of these exposures there are small stones unlike any of the rocks of this region. This is conclusive evidence of the existence of a stratum of glacial material underneath the loess over at least a portion of the county.

Nearly all of this soil was originally forested, but the more level areas have been cleared and cultivated. Most of the rougher parts are still covered with trees, mostly scrub oak, little merchantable timber being left.

Several large young apple orchards have been set out on the Miami silt loam and are making a very satisfactory growth. The trees grow less rapidly and to better shape on this soil than on the black prairie. The yields from orchards on this type should be more certain, owing to the increased hardiness of the trees. At Waverly, a few miles over in Lafayette County, there are extensive orchards on a similar soil, which are said to be very successful.

The principal crops grown on the Miami silt loam are the two staples, corn and wheat, and grass. Owing to its broken character, the fields cultivated are not so extensive as on the Marshall silt loam, and as a rule the yields are not so large. The average yield of corn is about 30 or 35 bushels and of wheat 12 to 14 bushels an acre.

The application of barnyard manure and the plowing under of the rotted straw seen in piles where thrashed would add organic matter to the soil, improve its structure, and also prevent to some extent its washing.

The following table shows the results of mechanical analyses of both the soil and subsoil of this type:

Mechanical analyses of Miami silt loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12346	1 mile W. of Cambridge.	Light-brown silty loam, 0 to 8 inches.	0.1	0.5	0.6	1.6	15.4	71.6	10.0
12348	2 miles E. of Marshall.	Light-brown silty loam, 0 to 8 inches.	.0	.1	.4	1.0	7.2	55.7	35.4
12347	Subsoil of 12346	Light-brown silty loam, 8 to 36 inches.	.0	.5	.4	1.8	8.6	69.8	18.6
12349	Subsoil of 12348	Heavy silty loam, 8 to 36 inches.	.0	.1	.2	1.9	6.7	66.6	24.4

CLARKSVILLE SILT LOAM.

The surface of the Clarksville silt loam, ranging in depth from 6 to 10 inches, is usually a yellowish-brown silty loam, although in some places the soil is an ashy-gray color, due to the incorporation of small amounts of organic matter. The subsoil, to a depth of 20 to 24 inches, consists of a yellow or light-brown heavy silt loam, below which there occurs a heavy red or yellow clay.

All of the Clarksville silt loam mapped in the area is found in the southern part of the county, in Salt Pond, Liberty, Salt Fork, Blackwater, and the southern part of Elmwood townships, and in two irregular shaped areas in Arrowrock Township, north of the village of Nelson.

The surface features of this type are quite rough and broken, although some rather extensive areas of gently rolling country are included within its boundaries. Certain portions of the type have been badly cut up by erosion and are extremely rough. On these eroded areas there is scarcely any soil covering, and they, as well as other rough areas, are not cultivated, being covered for the most part by a dense growth of scrub oaks. Its location along Blackwater Creek and important tributaries gives it excellent natural drainage, save only in a few places, where artificial drainage is feasible. Some of the surface soil is rather loose and does not well retain the moisture necessary for growing crops. The incorporation of organic matter by applying stable manure and by turning under the straw now allowed to rot in piles would remedy this trouble to some extent and also increase the productiveness of the soil. The heavy character of the subsoil aids in the conservation of moisture and in a measure compensates for the looseness of the surface soil.

The origin of the Clarksville silt loam in this area can be attributed to two widely different processes—glacial action and the disintegration of rocks in place. The surface soil of the greater part of the type is undoubtedly composed of or modified by the loess deposits spoken of elsewhere in this report, while the subsoil in most places is distinctly residual in character. The bed rock outcrops in many places, though the areas are too small to be shown on a map of the scale used. Saline County lies near the southern limit of glacial action, and the loess covering, not being very thick, has been partially removed by erosion; therefore the soils of the southern portion of the county are liable to be made up of the residual products of the disintegration of the underlying rocks, modified at the surface by the loess still remaining.

Apple orchards have been set out on this soil and are coming into bearing. This industry can be extended on the Clarksville silt loam probably with as much, if not more, profit than can be realized from the same crop on the Marshall silt loam. The trees grow less rapidly, are more hardy, and of better shape on this soil, and if properly cared for should produce equally as well or better. This soil type, however, is not so well adapted to wheat and corn as the Marshall silt loam, and sells at a much lower price. Corn will probably average about 25 bushels and wheat from 8 to 10 bushels per acre. In the southwestern part of the county, around Sweetsprings, much of the Clarksville silt loam is used for dairy farming.

The Clarksville silt loam is capable of considerable improvement, and should be carefully farmed in order to obtain the best results.

The following table gives the results of mechanical analyses of both soil and subsoil of this type:

Mechanical analyses of Clarksville silt loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
12340	1½ miles SE. of Ridge Prairie.	Brown silty loam, 0 to 8 inches.	0.0	0.3	0.4	1.9	9.9	74.2	13.3
12342	5 miles NE. of Sweetsprings.	Yellow silty loam, 0 to 10 inches.	.0	.1	.4	1.4	5.1	79.6	13.7
12341	Subsoil of 12340	Yellow silty loam, 8 to 36 inches.	.1	.3	.4	1.5	4.8	72.4	20.4
12343	Subsoil of 12342	Brown silty clay, 10 to 36 inches.	.0	.3	.3	.7	2.7	66.4	29.6

CLARKSVILLE STONY LOAM.

Unlike all the other soils of the county, the Clarksville stony loam is recognized by its rough stony nature. It is associated with the Clarksville silt loam and sometimes contains small areas of that soil.

The soil is a brown or yellow silt loam from 6 to 8 inches deep. The subsoil is usually a heavy red or yellow residual silty clay. Both soil and subsoil are more or less filled with angular fragments of chert and limestone. Sometimes the bed rock, strewn with loose fragments, appears at or near the surface.

The Clarksville stony loam is found in the southern part of the county where the loess mantle has been removed. It occurs in small irregular-shaped areas generally surrounded by the Clarksville silt loam. The topographic features are varied, but almost always consist of rough, steep slopes. Good natural drainage exists wherever this type occurs. Wherever the loess mantle has been removed, the materials giving rise to this soil are exposed. It is almost entirely residual in origin, being formed from the siliceous limestone on which it rests.

Very little of the Clarksville stony loam has been brought under cultivation. The native timber growth consists of oak, hickory, and other hardwoods, and although the wooded areas have long since been nearly stripped of merchantable timber, they furnish a considerable quantity of firewood and fence posts, with some little lumber for building purposes.

Where not too steep and rough this soil should prove valuable for the production of apples and other fruits. In the southern part of the State some of the largest apple orchards in the world are located on a soil of the same general description as this one.[a] The rougher stonier areas should be reforested so as to supply the increasing demand for firewood and fence posts.

The following table shows the results of mechanical analyses of the fine earth of this type of soil:

Mechanical analyses of Clarksville stony loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
12344	4 miles NE. of Wanamaker.	Brown silty loam, 0 to 7 inches.	0.4	1.4	1.3	5.0	8.1	66.8	16.8
12345	Subsoil of 12344	Red silty clay, 7 to 36 inches.	.4	.7	1.2	3.5	4.7	59.5	29.8

CLARKSVILLE LOAM.

The surface soil of the Clarksville loam consists of a gray or light-brown silty loam with a depth of about 12 inches. The subsoil is usually a brown silty loam slightly heavier than the soil. The soil is quite variable, sometimes becoming almost a sandy loam. It is found principally in Salt Pond Township along branches of Davis Creek and in Liberty Township along Blackwater River and Finnis Creek. It occupies nearly a level position in the narrow bottoms of these streams, and some of it is subject to overflow and often remains wet for some time after the waters subside. The Clarksville loam is an alluvial deposit, and is made up of the wash from the neighboring hillsides.

In favorable seasons this type produces good crops of corn, but at present little of it is under cultivation. It is generally in pasture and some areas are timbered, the forests furnishing firewood and fence posts, and occasionally a little lumber.

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[a] See Soil Survey of Howell County, Mo., Field Operations of the Bureau of Soils, 1902, pp. 599 to 603, inclusive.

The following table gives the results of mechanical analyses of this type of soil:

Mechanical analyses of Clarksville loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
12338	4 miles NE. of Sweetsprings.	Yellow silty loam, 0 to 12 inches.	0.1	0.3	0.5	2.3	10.3	70.0	15.9
12339	Subsoil of 12338	Brown loam, 12 to 36 inches.	.0	.7	.4	1.3	9.9	67.1	20.4

MEADOW.

The Meadow mapped in this area consists of a narrow strip of low, poorly drained land extending along Salt Fork Creek from the Lafayette County boundary to the mouth of Cow Creek. The fall of the creek in this distance, about 18 miles in a straight line, is less than 50 feet, and its course is so crooked that high water is not readily removed and the level land on each side is inundated.

The soil of this narrow strip varies from a heavy silt loam to a clay loam. Very little attempt is made to cultivate it, as crops are liable to be either wholly or partially destroyed by high water. The most of it is covered with a growth of soft maple, elm, oak, hickory, and honey locust.

If the course of the creek were straightened, the surplus waters would pass off much more rapidly and the greater part of these lands, it is believed, could be brought under cultivation. In Grand Pass Township some of the farmers owning land along the creek have straightened portions of the channel and diked low places to keep the waters from spreading out. These efforts have, it seems, been rewarded with success.

AGRICULTURAL METHODS.

The system of farming practiced in Saline County is for the most part typical of a rich corn-growing and stock-feeding section. It has been the custom on a large number of farms to grow corn year after year on the same fields, but at present more attention is being given to a rotation and more thorough tillage of crops. This change in methods seems to be due to the increased price of land and in a less degree to a slight decrease in the productiveness of exceedingly productive soils. The principal rotation is to alternate corn with wheat.

Corn is grown for two or three and sometimes four seasons in succession, followed by one or two crops of wheat. Oats are sometimes sown after corn instead of wheat, but the acreage in this crop is only about one-fourth that in wheat, and the acreage in wheat is slightly less than one-fourth that devoted to corn. The production of oats has decreased greatly, but wheat continues to be one of the leading crops of the county, not only on account of the direct profit derived from it, but also because it gives the soil a much-needed rest from corn and furnishes a nurse crop with which to seed clover. Although it has been the rule to follow wheat with corn, some of the better farmers who keep large numbers of cattle now sow clover or timothy and clover with the wheat. A few omit wheat from the rotation and seed clover with the corn. The land usually remains in grass for two years or more before being broken again for corn, and is used for grazing each season after the first crop has been removed for hay. Permanent bluegrass pastures, often mixed with white clover, which is self-sown, are numerous, but occupy only a limited area on some farms.

When preparing ground in corn the preceding year for the next corn crop it is customary to employ the more rapid method of listing it instead of plowing it level. The lister throws a furrow to each side and leaves the surface of the field a succession of low ridges and shallow hollows. The seed is planted in the bottom of these hollows and the first cultivation is done with a smoothing harrow, which levels the ridges and draws soil around the young corn plants. When wheat follows corn the usual method is to loosen the surface of the ground with a disk harrow and drill the seed in among the corn stubble, but when corn follows wheat the surface is broken with a turning plow.

Some of the more thorough farmers plow the whole surface of the fields to a depth of about 6 inches, then pulverize it well before planting, and practice shallow, level cultivation. This method is to be highly recommended, as it tends to conserve the soil moisture and rewards the farmer with increased yields. An occasional deeper plowing and more thorough, careful tillage than is at present practice is also to be recommended.

Only a small part of the corn crop is cut and shocked for curing. By far the larger portion of it is either husked or "snapped" without being husked, the stalks being left standing in the field. The young stock are turned into the fields and browse on these standing stalks during the winter.

Most of the hogs raised at present are Poland Chinas. A considerable number of Duroc Jerseys are also raised, as well as some Berkshires. Probably less than one-tenth of the cattle fed are raised in the county. The majority of them are bought in Kansas City, having been raised on the ranches farther west, and a considerable number come from the Ozark region, in the southern part of the State. They are mostly well-bred Shorthorns, although many Herefords and Polled Angus are also seen.

In the extreme southwestern corner of the county dairying takes the place of cattle feeding to some extent, and on many farms it is the principal source of income. Two creameries are kept in operation—one at Sweetsprings and the other at Emma, on the county line west of Sweetsprings.

The dairy farmers save the manure on their farms and apply it to the land. This practice, together with the feeding of large numbers of live stock in all parts of the county, is aiding greatly in maintaining the productiveness of the soils, which are very generally subjected to an exhaustive system of cropping. Commercial fertilizers are not used to any appreciable extent. The annual expenditure for this purpose, according to the census of 1900, is only $14,050, which is less than 3 cents' worth to each acre of land in the county.

The most improved machinery suitable to the various farm operations is in use by nearly all of the farmers. A relatively small number take excellent care of these implements, but the majority either leave them in the field where they were last used or pull them up near the farm buildings and allow them to stand there unprotected until they are needed the following season.

AGRICULTURAL CONDITIONS.

Nearly the whole population of the county is engaged in agricultural pursuits, and appearances indicate a degree of prosperity probably not exceeded in any other county of the State. A good school system, many churches, rural free delivery of mail, and the existence of a dozen newspapers evidence a spirit of progress and independence. The prosperous conditions, which in the main result from naturally productive soils, are further shown by the stability of nearly a score of banks. No manufacturing of any importance is carried on within the limits of the county; therefore the soil is the sole wealth-producing power.

The crops raised do not require any great expenditure for farm buildings. The country homes are usually commodious, comfortable one-story houses. Not needing any extensive shelter to house their crops, a great many farmers have neglected to provide suitable shelter for their stock and make little or no attempt to protect them during cold weather. Better shelter for the stock and proper sheds for the expensive farm machinery in use should be provided on nearly every farm in the county.

About one-half of the farms are operated by the owners. Many of these farmers are engaged in stock feeding, combined with the growing of grain, while the farms worked by tenants are used almost exclusively for the production of grain crops. Probably the most common method of renting land is that of paying a stated price per acre, this price not often falling below $5 an acre, and for choice corn land is often considerably more. A second method of renting is on shares, the renter giving from two-fifths to one-half of the harvested crop for the use of the land. Another method of operating, used to some extent, is to hire the crop grown, the owner paying from 7½ cents to 12½ cents per bushel of corn, or a stated price per acre.

About 90 per cent of the land of the county is in farms, of which only about 12 per cent is classed as unimproved. The number of farms is 3,638. There are many holdings of from 20 to 40 acres, and some exceedingly large ones, but the average size of the farms is 120.7 acres. The largest individual holding of real estate is 2,524 acres, but much of this is unimproved. Nearly all of the farms are well fenced. New wire fences of the most approved pattern are common, and are so built as to turn hogs as well as cattle. Osage orange hedges are seen in nearly every part of the county, but this kind of fence is not being extended. Many of the farmers are tearing it out and replacing it with wire. Very little of it is properly trimmed and cared for, and wire has to be used with much of it in order to turn stock. The importance of either improving and taking better care of these hedges, or doing away with them entirely, should be impressed upon every farmer, for when allowed to grow up in brush and briars, as is the case on some farms, a harbor is furnished for injurious insects, weeds, and animals, and valuable land is wasted.

Land values vary considerably. It is said that the highest priced agricultural land in the State is located on the Petesaw Plains, sales at $100 an acre being quite common. Some farms on these plains are held at $150 an acre, but at this price no buyers are found. The highest price yet realized for any land in this section is about $125 an acre. The high, rolling prairie lying east and south of Petesaw Plains sells at from $60 to $80 an acre, and choice farms at even more. Prices in the rest of the county will probably range from $35 to $60, but no definite prices can be cited for land in the bottoms. In the past thirty or thirty-five years farm values have increased from 75 to 100 per cent. Farm land was never higher in price in the history of the county than it is now, and the tendency is toward still higher prices. This is remarkable in view of the fact that these lands have been almost continuously cropped during the upward trend of prices.

One of the unsatisfactory problems with which the farmer has to contend is the character and efficiency of available labor. Wages paid farm hands employed throughout the year vary from $18 to $25 per month, and from $1 to $1.50 per day for day hands. Labor is both white and colored. The use of improved and labor-saving machinery has made possible the planting and handling of a much larger acreage than was formerly done and has partially solved the labor question.

The range of crops grown in Saline County is such that if the county were isolated from the rest of the country the people could still live without being in want of any of the necessaries, nor for many of the so-called luxuries of life. Indian corn is the dominant crop, about 40 per cent of the area of the entire county being planted to this cereal. Wheat is second in importance, the acreage being about one-fourth as much as that of corn. Clover and grasses are next in importance, with an area of about half that of wheat. Other crops produced are oats, rye, millet, potatoes, sorghum, fruits, and miscellaneous vegetables.

An idea of the extent of the stock feeding done in the county can be obtained when one considers that out of a crop of corn of 6,500,000 bushels raised in 1899 only about 5 per cent was shipped out of the county, whereas during the same season about 25,000 or 30,000 head of cattle were marketed which had been fattened in the county. Horses, swine, mules, and poultry also add greatly to the wealth of the county. In some seasons the production of corn is not sufficient to feed the stock kept, and the feeders have to look elsewhere for their supply. Only two other counties of the State exceed Saline in the value of live stock kept. The annual exportation of stock from the county amounts to more than $1,500,000.

Agriculture in Saline County has not yet developed to the point where there is any special adaptation of crops to soils. The different crops grown are planted on all of the soils, with possibly one exception, the Clarksville stony loam, which is not improved to any extent.

The public highway system is very complete and reaches every part of the county. The roads are generally pretty well cared for. In many places erosion has made the maintenance of wooden bridges expensive, and this is being remedied by the building of permanent stone or concrete culverts. Many substantial iron bridges also have been built and more are being added each year. There are no macadamized roads, but such an improvement should be considered by the county officials, as there is an abundance of excellent material easily accessible for such purpose, except in the northwestern part of the county.

Two competing lines of railroad cross the county. The river route of the Missouri Pacific Railway from Jefferson City to Kansas City crosses from the southeastern corner to the northwestern, and the Lexington branch of the same system between Sedalia and Kansas City crosses the southwestern corner at Sweetsprings. The

Chicago and Alton Railway, running east and west, divides the county into two parts. For passenger service the latter excels, but for freight traffic, which is more important to the farmer and stockman, there is not much choice, one being as good as the other for Kansas City shipments. The Missouri Pacific offers a more direct route to St. Louis and the East by that point, while the most direct route to Chicago and the East by that point is over the Chicago and Alton.

The population of the county in 1900 was 33,703, of which about one-eighth was colored. Marshall, the county seat, with a population of 5,086, is the largest town. Slater, a divisional point of the Chicago and Alton Railway, is a town of about 2,500 inhabitants, and Sweetsprings, in the southwestern part of the county, has a population of about 1,000. Other towns having a population of about 500 are Maltabend, Miami, Blackburn, and Nelson. As before stated, the county is strictly agricultural, and therefore offers scarcely any home market for the farm products. Kansas City, St. Louis, and Chicago are all easily accessible by rail and are popular markets for the products of the county.

SOIL SURVEY OF THE O'FALLON AREA, MISSOURI-ILLINOIS.

By **ELMER O. FIPPIN** and **J. A. DRAKE.**

LOCATION AND BOUNDARIES OF THE AREA.

The O'Fallon area lies in the form of a rectangle, with its southeast corner about 20 miles northwest of St. Louis. It is 28 miles long from east to west and 24 miles wide, containing 396,928 acres, or about 620 square miles, land surface. Geographically it lies between the parallels of 38° 40′ and 39° north latitude, and the meridians of 90° 30′ and 91° west longitude. The largest two rivers in the United States and a third of very considerable size flow through the eastern part of the area. About 68 square miles lying in Illinois, across the Mississippi River, forms the northeastern corner of the area. Through this part also flows the Illinois River. The Missouri River, entering the area from the south, takes a northeasterly course and soon leaves the area. All of these rivers unite a few miles east of the area. Kansas City lies almost due west, at a distance of 250 miles, and two direct lines of railroad connecting that city with St. Louis

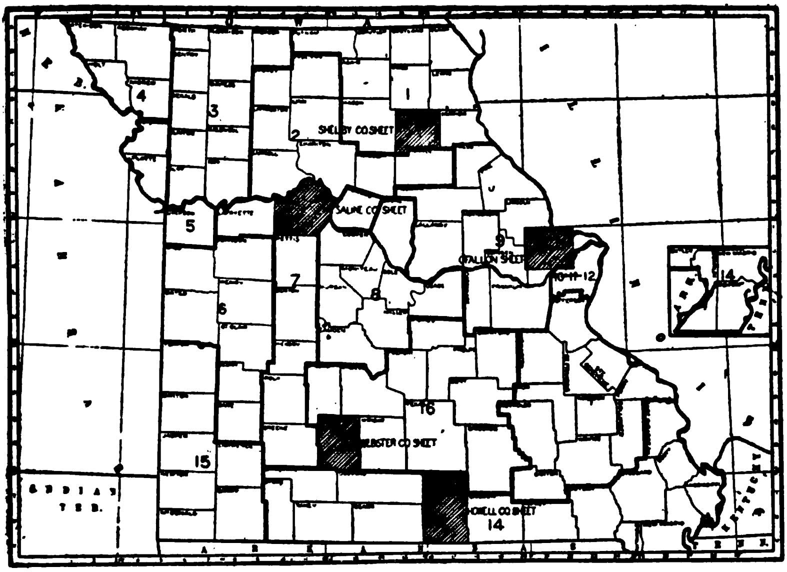

FIG. 34.—Sketch map showing the location of the O'Fallon area, Missouri-Illinois.

pass through the area. The Wabash Railroad traverses the uplands a little south of the center, while the Missouri, Kansas and Texas Railroad follows the north bank of the Missouri River. Three miles farther south a third main line, the St. Louis, Kansas City and Colorado Railroad, crosses the southeast corner of the area. The St. Louis, Keokuk and Northwestern follows the Mississippi bottom north, and a branch extends southeast from Old Monroe, connecting with the Wabash at St. Peters. Beginning at Old Monroe and extending westward below Troy there has been constructed, during 1904, a branch of the Burlington system. This branch will form part of a through line between St. Louis and Kansas City.

Parts of six counties are included in the survey. These are St. Charles, Lincoln, Warren, and St. Louis, in Missouri, and Calhoun and Jersey, in Illinois. The greater part of the area lies in St. Charles and Lincoln counties. The largest towns in the area, in the order of their size, are Troy, Wentzville, O'Fallon, St. Peters, Winfield, New Melle, and Brussels, each having a population of less than 1,500. St. Charles, a town of several thousand population, is situated just off the eastern border. Troy, the county seat of Lincoln County, is on the St. Louis and Hannibal Railroad, which connects with the Wabash at Gilmore. No railroads touch the Illinois part of the area, but there is boat service on both the Illinois and Mississippi rivers.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The present well-developed industrial system of the area had its beginning about three-quarters of a century ago. At that time the country was unoccupied, except for a few scattered white hunters who were associated with the earlier French settlement at St. Charles and with the American settlement made by the famous Daniel Boone below New Melle, just over the border of the survey. Forests covered most of the region, being found along all the streams and on the more broken country, while prairies occurred at a few points on the level upland divides, particularly in the vicinity of Wentzville, and were covered by the characteristic "prairie grass." Prairies also occurred on the Mississippi bottoms. On the hills oak, hickory, and walnut were the most abundant forest species, and in the bottoms elm, hackberry, sycamore, box elder, and maple.

Some permanent settlers, carrying a mixture of French blood, naturally came into the area by way of St. Charles, and through Boone's efforts settlers from Virginia and Maryland entered the western part, but of far greater importance was the German immigration, which became active about 1833. Descendants of those people now form the bulk of the population. It is noteworthy that the timbered land on the hills and in the bottoms was the first occupied by the settlers, and that the prairies were the last to be brought under cultivation because they were thought to be of low productive power.

Grain farming after the methods of the times has been the chief agricultural industry since the first settlements were made, though the raising of live stock, first for home purposes and then for market, has occupied an important place. Lately there has been a tendency to increase the dairy output, a large part of which takes the form of milk and cream for the city market. Fruit has been grown to some extent from the very beginning, and has advanced to a position of some commercial importance. Old apple orchards, several acres in extent, are sometimes seen, being more numerous in the eastern than in the western part of the area. The marked success of some of these has caused very large plantings in recent years, some of which have come into bearing with satisfactory results. In Illinois especially and near St. Charles the planting of both apple and peach trees has been carried on very actively during the last two years, so that in a few years more the region will rank with the leading fruit producing sections in the States of Missouri and Illinois. In the southern part of the area large wine cellars have been in existence for forty years or more, and large vineyards are still maintained.

CLIMATE.

A fair idea of the climatic conditions in the area surveyed may be obtained from the following table, taken from the records of the Weather Bureau stations at St. Charles, St. Louis, and Warrenton, which shows the normal monthly and annual temperature and precipitation:

Normal monthly and annual temperature and precipitation.

Month.	St. Charles.		St. Louis.		Warrenton.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	° F.	*Inches.*	*° F.*	*Inches.*	*° F.*	*Inches.*
January	31.0	2.06	30.5	2.18	29.8	2.26
February	31.4	3.07	35.1	2.78	29.8	2.63
March	42.5	3.16	43.1	3.49	41.1	3.81
April	55.9	3.19	56.2	3.79	55.6	3.71
May	64.2	4.29	65.8	4.58	65.2	5.04
June	74.0	4.36	75.2	5.06	73.8	4.87
July	77.8	3.35	78.8	3.76	77.8	3.57
August	76.2	2.71	76.8	3.50	76.8	2.32
September	68.8	2.55	69.4	3.12	68.5	3.34
October	57.7	2.30	57.5	2.89	55.7	2.38
November	44.1	2.92	43.6	3.10	42.3	2.76
December	35.0	2.18	35.6	2.81	32.6	2.54
Year	54.9	36.14	55.6	41.06	54.1	39.23

From these data it appears that about 57 per cent of the rainfall occurs during the six months of the growing season.

PHYSIOGRAPHY AND GEOLOGY.

The uplands exhibit a pleasing diversity of rolling and hilly topography, which in a few places becomes distinctly rugged. The Mississippi River receives directly probably 80 per cent of the drainage through its chief tributaries—the Cuivre River and Peruque and Dardenne creeks. The elevation of the area ranges from a little more than 400 feet along the rivers to about 850 feet at the highest point on the uplands in the southwestern part, 6 miles west of New Melle. Hence the general slope is eastward. Callaway Creek is the only important stream flowing into the Missouri River. The central part of the area is the most level and consists of broad divides which lead by long, graceful slopes to the streams. The country around Wentzville, Josephville, and Dardenne and that northwest of New Melle is of that type, but none of the region is at all flat. Frequently the streams, even in the section just mentioned, are bordered by abrupt bluffs from 60 to 100 feet in height, while toward the northern, western, and southern borders of the area the country becomes more hilly, and around the heads of Big and McCoy creeks in the west central part, and along Callaway Creek and the Missouri River in the southern part, the surface is very broken. The drainage system, in general, is of the ramifying type and the valleys of the main streams and their tributaries are lined by steep limestone bluffs, sometimes 200 feet in height. All the smaller streams wind through narrow areas of flat bottom land, the material of which has been carried from the surrounding hills. Along Cuivre River these bottoms are nearly a mile in width. All except the larger streams are without running water during most of the year and serve chiefly to conduct the water during rains, when it runs off very rapidly and is very destructive to the stream banks. The water sometimes reaches a height sufficient to overflow the bottom lands and damage crops. During times of heavy rainfall great gullies form in the steeper hillsides, which hinder cultivation of the fields and greatly decrease their productiveness.

The upland country on the Illinois side consists of a strip about 4 miles wide that extends southeast between the bottom land of the Illinois River and the main channel of the Mississippi River. The latter stream, during most of its course, washes against a steep bank from 100 to 250 feet in height, the lower half of which is composed of limestone. The drainage is by several short streams toward the east. The surface is very hilly throughout, but, unlike most of the part of the area in Missouri, the slopes do not contain outcropping rocks. In the vicinity of Beechville there is much of the kettle hole topography, which is found only infrequently in other parts of the area.

The large river bottoms occupy about 165 square miles of the area. Along the Mississippi they are from 4½ to 6 miles wide; along the Illinois the width is from 2 to 4 miles, and along the Missouri River the width is a little over 3 miles. These constitute the inner gorge of the rivers and are bounded by steep walls, for the most part founded on and composed of limestone. At some time in the past the main streams meandered over all of these bottoms, and their former position is indicated by the numerous winding, shallow depressions, or old slough ways. All of these contain water at certain seasons of the year, and some of them are constantly filled, forming the horseshoe lakes and side sloughs. The surface in general is flat, slightly modified by depressions and ridges. The part near the bluffs is usually slightly lower than the stream bank. Along the Mississippi River this has caused the formation of large prairie areas, which are covered by tall, wiry grass and sedge. During the greater part of the year these lands are covered by a few inches of mud-laden water.

In the Mississippi and Missouri rivers appear a number of islands, several of which are a square mile or more in extent. These were formed first as sand bars, and when raised to a sufficient height they received only the finer particles during high waters. The upstream portion and the shores received the coarser and larger deposits, while the lower interior received the finer particles from the more quiet water.

The two geological formations most important in their relation to soils belong to the Quaternary period, and consist of a thick mantle of loess over all the hills, and the later alluvium in the bottoms. From a depth of 30 or 40 feet in the eastern part of the area, the loess thins to an average depth of about 4 feet on the western border. With this thinning there is an increase in the clay content and a decrease in the characteristic properties of true loess. Typical loess is composed of two-thirds silt, and is rich in lime carbonate and iron compounds. The former of these is present here only in very small amounts, especially in the heavier material on the western side. No tubes or nodules of importance were observed during the progress of the survey. In the heavier material of the western part of the area small iron concretions of buckshot size frequently occur. In fact, "buckshot land" is a term locally applied to such soil. The thinner material exhibits many of the qualities of clay in its cleavage structure. It breaks into small angular fragments that are very hard when dry, as are also the dry walls of the material. In the eastern part of the area and in Illinois the clayey stratum is less thick and heavy, and grades downward into pure mealy silt of massive structure, while a considerable part of the lower material is of a light-gray color and frequently grades downward into fine sand. At several points near the Mississippi River sections 40 feet in depth were observed, in which the clayey surface material graded downward through silt and fine sand to medium sand at a depth of 15 feet, below which the material was of finer texture and more distinctly stratified, until at the base occurred a dense blue mud. The loess is by far the most important soil-forming material in the area and has given rise to all the upland silt loam types, and, a little less directly, to several of the lowland types.

As a rule, the loess rests directly upon rock ledges or on the residual product of such rock, but it is probable that some glacial till intervenes in a few places between the silt mantle and the bed rock. Till was not observed except at one point on Sam Creek, 5 miles southwest of Wentzville, but glacial bowlders are frequently seen in the western part of the area, and at points sufficiently high to preclude their having been carried there in the present drainage.

The rocks exposed at the surface consist almost entirely of limestone of every type of bedding, together with sandstone and some mud rocks. In the eastern part the Coal Measures are represented, and coal has been mined at a number of points. The seams, however, are at present not profitable for working. Passing westward, increasingly older rocks are exposed through the lower Coal Measures and the St. Louis and Trenton limestones, down probably into the magnesian series of the Paleozoic age. The accuracy of these correlations, however, can not be verified, because no systematic study of the detailed geology of the region has been made. It is sufficient for our purpose to know that rock formations of the kind enumerated do occur. These rocks are represented in the soils only on the steepest slopes, where fragments of them occur at the surface, mixed with some residual material and with silt washed from the loess, and are all included in one type.

The alluvium consists of the material deposited by the streams at flood times in the wide bottoms or flood plains and as bars and islands in the main stream. It comprises a variety of materials arising from the various currents and conditions of deposit, and ranges from coarse sand to very heavy, tenacious clay. The material nearest the stream, and hence at times of overflow in the swiftest current, is of the coarser texture.

The three bottoms exhibit individual peculiarities in the materials composing them. In the Illinois bottom the material contains very little sand, and the position of the stream is quite stable; along the Mississippi the sand is distinctly noticeable near the stream, though largely masked by finer grades of material; but along the Missouri River sand is abundant at the surface in many places and underlies all the heavy material at a short distance below the surface. The current of the latter river is much the swiftest of the three, and tends to change the course of the stream rapidly by eroding away the banks. This process is more rapid during rising water and an inshore wind. The basal fine sand is quickly washed out and the upper material drops into the river in great blocks. Hundreds of acres of excellent farming land have been removed in this manner, and 15 or 20 acres are sometimes taken from a single curve in one season.

With the exception of a few very high points in the Mississippi bottom near Portage des Sioux, all of these lowlands are subject to overflow by the high waters of the rivers. Sometimes all the islands are covered, most of them are at frequent intervals, and in June, 1903, the overflow water reached a depth of 10 feet at many points. During most seasons, however, no such great depth is attained, and in two or three years out of five a full crop is insured on most of the cultivable bottom land.

SOILS.

The soils of the area have been divided into ten types, of which four occur exclusively on the uplands, two are developed in the small valleys, and the remainder occur in the bottoms of the large rivers. The increase in the proportion of clay in the loess formation from the eastern margin of the area to the western margin has been made the basis for the division of the silty material into different types. The line of division is an arbitrary one and does not indicate that there is any sudden change in the character of the material, but it is intended rather to separate the more clayey part, the western half, from the less clayey part, the eastern half. This division corresponds in general to the crop interests in the two parts. Fruit has been found to succeed best on the more silty soil, and the distinctly clayey portion is devoted more exclusively to cereals and the grasses.

The names and extent of the several types are given in tabular form below:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Marion silt loam	175,552	44.2	**Yazoo loam**	16,640	4.3
Waverly silt loam	57,088	14.4	**Memphis silt loam**	5,876	1.8
Miami silt loam	54,656	13.8	**Miami fine sand**	1,728	.4
Yazoo clay	31,936	8.0	**Sioux sandy loam**	320	.1
Rough stony land	30,208	7.6	Total	396,928	
Waverly clay loam	23,424	5.9			

MIAMI SILT LOAM.

The soil of the Miami silt loam is a brown or gray silt loam with an average depth of about 14 inches. There is some variation in the texture of the material in different parts of the area. As already pointed out, there is a gradual increase in the content of clay as the areas extend toward the west, and this makes the soil as found south and west of the Mississippi River somewhat heavier than that developed east of the river. In the area between the Illinois River and the Mississippi River the soil is relatively coarse, more friable, and contains a higher percentage of very fine sand. The variation in the color of the surface soil is due to erosion, the lighter tones occurring on the slopes, where the wash is greatest.

The subsoil is a yellow or light-brown clayey silt loam, showing the same peculiarity of increasing clay content from east to west. The material is seemingly massive, but has a coarse cleavage structure, with fine sand distributed along the joint planes. When containing a moderate quantity of moisture it breaks down into a friable loam, but when dry it is rather hard. This coarse, flaky characteristic of the subsoil is most pronounced east of the Mississippi River. In the eastern areas, beneath this clayey stratum, the material becomes nearly a pure silt, but in the western limits of the type this difference in the deeper subsoil is not so apparent.

Where the loess deposit is thickest and the slopes are steep, the erosion has been so great in many places that the surface clayey stratum has been removed, and the subsoil is composed of the purer silty material. This is the character of the type on the steep slopes in the Illinois areas, and the resulting soil has a very different crop value from that of the steep slopes of the Marion silt loam, derived from the most clayey phase of the loess deposits.

The Miami silt loam includes that part of the loess formation in the eastern half of the area. It occurs in three bodies, separated from one another by the Illinois and Mississippi rivers, and the several bodies are cut by narrow strips of valley soils and by Rough stony land on steep hillsides. The western margin of the type has a general north and south direction and lies from one to several miles west of the rim of bluffs on the western side of the Mississippi River. It is an irregular line, in large degree arbitrarily placed, as already mentioned, and is drawn along streams over a large part of its course. The greater part of the type lies in Missouri. The Illinois area, which is divided into two bodies by the Illinois River, contains only about 68 square miles.

All of the Miami silt loam is rolling or hilly, the elevation ranging from 50 to 250 feet above the level of the large river bottoms. Small drainage streams, which have their sources in the upland, traverse the type, and adjacent to these the slope is frequently quite steep. The hilliest area lies east of the Illinois River, and consists of two narrow ridges. A rocky outcrop separates these ridges into two levels, the lower of which, though very rolling, has rather more gentle slopes than the higher.

The drainage of this type is good. The surfac
to prevent any considerable accumulation of wat
character of the soil permits it to absorb moisture
standing the latter quality, the steep hillsides in al
are subject to destructive washing during heavy ra
lies are formed that are a great hindrance to cultiv

The native timber is more thrifty and consists o
of species than on the Marion silt loam. There is
maple, basswood, boxelder, elm, hackberry, hickory

The fruit industry has its greatest development c
In Illinois there is a large number of bearing app
have been profitable for a number of years. Alon
Mississippi River in Missouri apples also form an i
The uniform success of these old orchards has led
many hundreds of acres of young apple trees witl
three years, and while these have not come into be
tion indicates the peculiar adaptation of the s
Most of the orchards lie between the Mississippi
ers. Peaches are also said to succeed well, but
ities for rapid transportation has prevented thei
any great extent. Late truck crops and berrie
quantities of potatoes are grown, the yield rangin
bushels per acre. The cereals, grass, and clover
Corn produces from 40 to 80 bushels, wheat 18 t
bushels, and hay from 1½ to 2 tons per acre.

Most of the type is valued at from $40 to $80 an
rough land overlooking the Missouri River and e
River has a lower value, and some small areas m
than $10 an acre, a price in part due to location as

The following table gives the results of mech
samples of the soil and subsoil of this type:

Mechanical analyses of Miami silt loan

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm
			P. ct.	*P. ct.*	*P. c*
10830	4 miles W. of Brussels, Ill.	Brown silty loam, 0 to 18 inches.	0.0	0.2	0.
10832	3 miles S. of Brussels, Ill.	Gray silty loam, 0 to 18 inches.	.1	.3	.
10831	Subsoil of 10830	Brown clayey silt, 18 to 36 inches.	.0	.2	.
10833	Subsoil of 10832	do	.0	.0	.

The soil of the Marion silt loam to a depth of from 10 to 15 inches is a dark colored to gray silt loam. The color varies with the proportion of organic matter present and is darker on the broad divides and lighter where the surface is more hilly and erosion has been active. The surface soil is also deeper and more friable on the more level areas than on the slopes.

The first 4 or 5 inches of the subsoil in the areas of darker soil is a light-brown silty clay, changing gradually to a more silty yellow material at a depth of 30 inches. In the rougher portions of the type the upper part of the subsoil is frequently a very fine sand and silt of a light-gray color, changing with depth, as in the former case, to light yellow. In general, the upper part of the subsoil is heaviest, i. e., contains the most clay, and there is a gradual increase in the proportion of silt with increase in depth.

In the western part of the Marion silt loam, and particularly where the surface is very rough, the soil over areas of a few square rods has been washed away and a heavy clay exposed at the surface. The difficulty experienced in cultivating these places has led the farmers to apply the term "hardpan" to them, and there are also other places where the subsoil is nearer the surface than is usual to which the same term is applied. The soil in a number of such areas was examined, but the material did not appear to contain perceptibly more clay than in adjoining areas where the hardpan character was absent. The high percentage of clay in the upper part of the subsoil causes it to become very dense when dry, and this is probably the only cause of its being so intractable. A characteristic of the subsoil is its granular structure, which is the finest in the upper part, the granules ranging in size here from less than a grain of wheat to flakes much larger in the lower part of the soil section. The granules are angular and when dry become very hard. They are the result of a complex arrangement of joint planes in the loess formation.

As might be inferred from the description of the loess given in the chapter on geology, the Marion silt loam is more clayey in the western part of the area than in its eastern limits. It also thins out from the east toward the west, and from the crest of the divides to the margin of the streams, where the inclination of the slope is greatly increased. From this condition arises the thinness of the soil in the latter position, where, over small areas, a flinty residual material occurs within 2 feet of the surface.

The soil of a large part of this type, particularly of the light-colored phase, contains a large quantity of small, rounded iron concretions the size of buckshot. They are less abundant in the subsoil, and gradually diminish in number toward the east. The upper 20 inches of the subsoil is usually mottled with reddish brown, and in the western areas of the type the lower part of the section is frequently stained slightly red, probably by the underlying red residual clay.

None of the Marion silt loam is found in the eastern half of the area surveyed, but nearly all of the upland in the western half of the area is occupied by it. The surface is rolling and hilly, and may be separated into two topographic divisions. The first includes very rough, broken land adjacent to many of the streams, and the second the high, broad divides between the larger streams. The surface of these large divides is not level, but lies in long, graceful swells, some of which reach by a moderate slope to the streams.

There are six streams of considerable size crossing the part of the area occupied by this soil, all flowing in an easterly direction. Small tributaries flow into them from the north and south. The general contour of the country has been formed by long-continued erosion of calcareous rocks, and at some points deep gorges occur, while at others are found broad valleys. The roughest areas of the soil are found where deep, narrow gorges prevail. A few of the most important of these rougher areas are: North of Cuivre River, including nearly all of the country drained into Bobs Creek; along Indian Camp Creek, and Big Creek west of its union with the former, and around the heads of the tributaries of McCoy Creek west of Flint Hill, where the greater part of the type has this character of surface; and in the southwestern part of the area along Calloway Creek, Dardenne Creek, and Little Dardenne Creek. In general, the Marion silt loam of this character of topography is associated with Rough stony land. Along Peruque Creek between Gilmore and O'Fallon is also some very rough country.

The more important of the broad divides with gentle slopes are south and east of Troy; west of Highview; from Foristell to Wentzville, and from thence to the region around St. Paul by way of Gilmore and Josephville; and nearly all of the divide between Peruque and Dardenne creeks, and around the head of the latter creek to Cappeln. The soil with the rougher topography is in large part very difficult to cultivate because of the steep slopes, but the broad divides offer no hindrance to the use of ordinary farm machinery.

The drainage of this type of soil is not very good. On the contrary, east of Wentzville, east of Flinthill, and at many other points in the most level areas in the extreme western part of the area the drainage is decidedly poor. Even on the slopes the drainage very often is defective. This condition is due to the heavy and impervious character of the subsoil. Rain water sinks readily into the upper soil, especially in the darker areas, and when the precipitation is heavy the subsoil becomes thoroughly saturated with moisture, which it gives up very slowly. The large amount of water retained by the subsoil and soil injures growing crops by drowning, and tends to severe heaving in winter. This can be plainly seen in wheat and grass fields in early spring. The tendency to retain water also makes the ground late for spring planting, by keeping the soil cold and by hindering cultivation. To correct this unfavorable condition of drainage tile drains are necessary. These should not be laid very deep; not over 2½ feet below the surface, nor should tile drains be confined to the more level areas, for they will be found of benefit even on decided slopes. Under the conditions existing in this type of soil, surface drainage, though helpful, is far from satisfactory.

As in the Miami silt loam, the surface of the steep slopes, particularly in the eastern part of the type where it contains most silt and is deepest, is washed badly by heavy rains, and once gullies are started their extension is difficult to prevent.

The origin of the soil from the weathering of the loess has already been noted.

The upland prairies, as they existed at the time of the settlement of the country, were formed of this type of soil. The largest areas were located around Wentzville and extended more or less continuously to St. Paul; and also on the divide south of Peruque Creek from the town of Dardenne westward. All were covered by prairie grass, and, though fringed by low shrubs, are said to have been free from tree sprouts.

There is a difference in the valuation of lands of this type, due, in part, to the surface features and the distance from shipping points. The remote rough land is worth from $5 to $20; the more level and better farming land from $30 to $60 an acre; and in some of the most favorable locations the value is even higher.

The type is well adapted to the production of grains, grasses, and leguminous forage crops, and the heavier areas make a better wheat than corn soil. It is admirably adapted to the production of the forage and pasture crops. The supply of organic matter, however, should be increased and maintained by the growth of leguminous crops and by the addition of any other available organic remains, and along with these potash and phosphate fertilizers would be helpful. Deep plowing in breaking the soil and shallow level cultivation are recommended for this type. All crops grow better on the dark-colored than on the light-colored soil. The latter can be greatly improved by the use of manures, deep plowing, and careful cultivation, and instances were seen where this part of the type had been made to give as good yields as the more level parts.

The crops grown are corn, wheat, oats, and hay. For hay, both timothy and clover are used. Considerable difficulty has been experienced in recent years in getting a good stand and growth of clover. Bluegrass occupies the soil naturally on the lighter textured areas of the type, but its growth is slow and weak where the soil is light colored. It is, however, the principal pasture grass. On the dark loam soil the average yield of corn is about 35 bushels; of wheat, 18 bushels; of oats, 35 bushels, and of hay, from 1 to 1½ tons per acre. In the most favorable seasons the yields are much larger, corn yielding as much as 70 bushels, wheat 30 bushels, oats 50 bushels, and hay 2 to 2½ tons per acre. The yields in either case on the rougher areas are less than the figures given. Potatoes and late truck grow fairly well and small fruits make good returns. Tree fruits have not been grown to any great extent. A few old apple trees, nearly beyond their bearing stage, were observed. Within the last few years a good many apple and some peach trees have been planted near New Melle, Foristell, and Wentzville, and the growth of these trees has thus far been satisfactory. Plums will succeed better on this heavy soil than peaches or cherries.

The following table shows the results of mechanical analyses of typical samples of the Marion silt loam:

Mechanical analyses of Marion silt loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10842	2 miles NW. of O'Fallon.	Gray silty loam, 0 to 16 inches.	1.0	1.7	0.6	0.5	5.1	75.1	16.0
10965	3 miles S. of Wentzville.	Dark silty loam, 0 to 18 inches.	.5	2.5	1.1	.8	1.4	75.8	17.7
11239	¼ mile E. of Wentzville.	Silty loam, 0 to 17 inches.	.6	2.1	1.2	1.2	1.6	74.3	18.3
10766	3 miles SW. of Winfield.	Gray silty loam, 0 to 17 inches.	.2	1.2	.7	1.1	5.8	70.8	20.0
11240	Subsoil of 11239	Silty clay, 17 to 36 inches.	Tr.	1.1	.7	1.2	1.2	62.1	33.4
10767	Subsoil of 10766	Brown silty clay, 17 to 36 inches.	.1	.4	.3	.6	3.6	59.1	35.9
10843	Subsoil of 10842	Stiff clay, 16 to 36 inches.	.3	1.1	.5	.8	3.1	58.2	36.1
10966	Subsoil of 10965	Clay, 18 to 36 inches	.4	1.0	.5	1.0	1.5	53.2	41.6

MEMPHIS SILT LOAM.

The soil of the Memphis silt loam, to an average depth of 16 inches, consists of a grayish-yellow silt loam of a loose, friable character that responds readily to cultivation. The color is the result of a considerable accumulation of organic matter, together with small amounts of oxides of iron. The subsoil is a light-brown or yellow silt loam, soft and mealy in its upper part, but usually heavier and noticeably clayey at 36 inches below the surface. Much of the type encountered in the area has a distinctly coarse cleavage structure, but is easily broken apart, unless very dry, when it is moderately resistant. In other places the material is a soft mealy silt to a depth of several feet.

The type occurs in the extreme southeastern part of the area on the point of highland between the Mississippi and Missouri rivers, and in another area on the south side of the latter stream, where it is most typically developed. The surface is distinctly hilly, as a result of pronounced stream action, but in only a few places along the river bluffs is it sufficiently rough to prevent ordinary cultivation. The slope of the surface and the porous nature of the soil to a depth of several feet provide thorough drainage. Where the slope is excessive, erosion is active, and this troublesome tendency of the soil must be constantly guarded against.

The type is derived from loess, and represents that phase which contains the least clay. It grades westward imperceptibly into the Miami silt loam.

All the crops common to the region are grown on this soil. Corn usually yields from 45 to 60 bushels, wheat, 22 bushels; oats, 40 bushels, and hay from 1 to 1½ tons per acre. The character of the soil is such that it is less affected by seasonal variations, especially rainfall, than perhaps any other type in the area. Water is readily absorbed, and its movement is sufficiently free to prevent excessive accumulation at any point which would cause injury by drowning or freezing the roots of crops. Owing to its texture and structure, large amounts of water are retained in the soil for long periods, and by careful management the crops may withstand protracted droughts with little injury. All forms of tree vegetation make a strong and luxuriant growth. The forest species include elm, maple, oak, hackberry, hickory, walnut, basswood, and boxelder. Fruit trees also make an excellent growth and are long lived. Apples, peaches, cherries, and plums among the tree fruits, and strawberries, raspberries, blackberries, currants, and grapes in the small fruit class, grow very well on this type of soil, and are produced in considerable quantities. Near St. Charles and below the Missouri River are several profitable apple and peach orchards, as well as some vineyards.

The soil is fairly well adapted to all the ordinary grains, grasses, and leguminous forage plants, and is perhaps better suited to the growing of corn than to the finer-rooted wheat. It is admirably suited to the growing of apples, peaches, and cherries, and to a variety of small fruits. No other type in the region so fully unites the essential requirements of a general-purpose soil.

The following table gives mechanical analyses of typical samples of this soil:

Mechanical analyses of Memphis silt loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
10963	1 mile NW. of St. Charles.	Gray friable silt, 0 to 16 inches.	0.0	Tr.	0.3	0.3	3.3	85.7	10.3
10964	Subsoil of 10963	Yellow silt, 16 to 36 inches.	.0	.0	.2	.2	2.8	87.2	9.5

ROUGH STONY LAND.

Rough stony land includes all those parts of the area where stones are a part of a soil formation. The surface material, which has a depth of from 8 to 30 inches, is a dark-colored silt loam that contains from 10 to 40 per cent of rock fragments, chiefly limestone, generally less than 3 inches in diameter. Beneath this silt occurs either a loam or a heavy, variously colored, silty residual clay, containing from 15 to 65 per cent of rock fragments; or, again, the silt may rest directly on the bed rock. This latter condition is most common on the steeper slopes.

The type occurs in every part of the area on the steeper slopes along the streams. It is most abundant along Callaway Creek and the tributaries of Wolf Creek in the southwestern part, and along the upper course of Big Creek in the west-central part. None of the areas are large or continuous for a long distance, and their occurrence depends on the character of the slope.

Rough stony land is really the result of the outcropping of the rock formations underlying the loess, from which some silt has been washed and mingled with the residual material from the rocks, or which, mingled with organic matter, forms a thin veneer over their surface. The surface usually lies at a considerable angle, and at several points nearly vertical ledges of rock occur. On the east side of the Mississippi River a part of the ledge is composed of sandstone, and sand is sometimes present in the soil in noticeable quantities. It is needless to add that the drainage of this soil type is thorough. The surface is too steep to permit ordinary cultivation, and nearly all of it is occupied by timber, consisting chiefly of oak and hickory in the western part, with a mixture of elm, maple, and other species in the eastern part. Where the soil is shallow the timber growth is small.

A few small areas have been cleared and planted to peaches and apples, but success can not be assured. Occasionally very small areas are included in cultivated fields. In orchard planting care should be taken to select areas where there is a sufficient depth of soil to sustain the tree in dry seasons. The character of the original timber may be taken as a guide in this matter. Some of the type might also be utilized in grape production. The relatively large quantity of organic matter in the soil, however, might stimulate too large a growth of wood and thus impair the quality of the fruit.

WAVERLY SILT LOAM.

The soil of the Waverly silt loam to a depth of 18 inches or more is a yellowish-gray to brown silt loam, in which may be seen a considerable quantity of very fine gray sand. Throughout much of the type a silt loam very similar to that forming the top soil extends to a depth of from 4 to 6 feet. The material is often roughly stratified, and thin bands of very fine sand and silt of light color are included.

This soil occupies the lower level along all the smaller streams, and forms a narrow ribbon through which the stream channel winds. It also occurs in narrow areas in front of the river bluffs. In this position it is found in every section of the area, but the largest bodies are seen along the Cuivre River and Dardenne Creek, and in front of the river bluff north of O'Fallon. Here the area attains a width of a half-mile or more. The surface is nearly level, with a slight upward slope to the bluff below which it occurs. The areas are also slightly higher next to the stream. A great part of the type is subject to overflow at infrequent intervals.

The Waverly silt loam owes its origin to this process of erosion and overflow, and represents the material washed from the loess, which occurs at a higher level. In the process some of the clay is carried away in the water while the sand and silt, mingled with organic matter, are deposited.

The texture of this type, which varies with the conditions of deposition, is finest along the Cuivre River and coarsest near the heads of the smallest streams, in which latter position the silt frequently rests on a mass of rock fragments and residual material at a depth of 2 feet. Along a number of streams in the northern part of the area 12 or 15 inches of light-colored silt rests on 2 feet of heavier silt of a darker color, which grades downward into a less heavy and lighter colored silt. The lighter surface portion probably represents the material deposited since cultivation began. Except at times of overflow the type is well drained. The rapid rise of the streams and their consequent overflow can not well be prevented, and in the bottoms the crops are occasionally destroyed in this way.

This type of soil is easily worked at almost any season, and presents no serious hindrances to cultivation. It is naturally very productive and has good moisture-conserving power.

It is cultivated to grains and grasses, and the yields are large. Corn sometimes yields from 60 to 100 bushels, wheat from 20 to 30 bushels, oats 50 bushels, and hay 2 tons per acre. It is a better soil for corn than for wheat, because it is light and warm, while the high content of organic matter causes wheat to lodge badly. It is well adapted to the production of potatoes, late truck, and melons, and in some places strawberries would do well.

The following table gives mechanical analyses of typical samples of the Waverly silt loam:

Mechanical analyses of Waverly silt loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10838	1 mile SE. of Brussels, Ill.	Silty loam, 0 to 14 inches.	0.1	0.4	0.2	1.0	18.4	71.3	8.5
10768	½ mile E. of Owen ...	Brown silty loam, 0 to 18 inches.	.0	.3	.1	.5	5.6	73.3	20.1
10769	Subsoil of 10768	Brown silty loam, 18 to 36 inches.	.0	.0	.1	.6	8.4	76.5	14.3
10839	Subsoil of 10838	Silty loam, 14 to 36 inches.	.1	.2	.2	.6	9.4	72.0	17.5

WAVERLY CLAY LOAM.

The Waverly clay loam, to a depth of 10 inches, is a heavy gray silt loam. From 10 to 18 inches below the surface there usually occurs a mixture of light-gray silt and very fine sand, beneath which is found a heavy drab or pale-yellow clay that extends to a depth of from 4 to 20 feet and rests on sand. In a few places the soil is quite dark, owing to the accumulation of organic matter.

The type is confined to the bottom lands along the Mississippi and the immediate tributaries of that river. The largest bodies, several square miles in extent, are located between the Cuivre River and Dardenne Creek. Small bodies are distributed along the Cuivre River as far up as Moscow Mills, and along Big and Dardenne creeks in the uplands. The surface is level and nearly flat and is traversed by a very few abandoned stream courses that have been nearly filled up with deposits from frequent overflows. These courses occur in such a way, however, that they are frequently the means of backwater.

The flat surface, the impervious character of the subsoil, and the position of the type tend to interfere with drainage. Water accumulating from rain or other sources disappears slowly, and these conditions have developed a very distinctive timber growth, which consists almost entirely of pin oak, and gives rise to the local term "pin-oak land." The large area of this soil adjacent to the Cuivre River on the main bottom is nearly all in timber of this character. The other areas are mostly cleared and under cultivation. The greater part of the type is within the flood plain and is subject to occasional overflow. The surface is usually highest next to the bluff, and areas in this position are seldom flooded, except in limited areas from the small streams from the uplands. Such is the position of the type near Winfield and Brevator. Its occurrences along the Cuivre River to a point 5 miles southwest of Old Monroe lie particularly well, their elevation being from 20 to 40 feet above the ordinary level of the stream. These bodies, of course, are never overflowed, and because they do not receive deposits from floods are somewhat less productive. They are somewhat lighter than the typical soil and closely resemble the heaviest phase of the Miami silt loam.

The clay subsoil was probably deposited by slow-moving flood waters, under conditions similar to those under which additions are at present being made to the Yazoo clay. These deposits have been modified and later covered by silt carried down by the streams from the uplands and deposited from the water when it spread beyond the banks. It will be observed from a study of the map accompanying this report that the type occurs adjacent to these local streams and forms a transitional type between the Waverly silt loam and the Yazoo clay. The light color of the upper subsoil results from the leaching of the water along the top of the impervious clay that forms the lower subsoil, and the fact that the upper part of the soil section is largely a silt indicates that there was a considerable movement of the water from which deposition occurred. Mixed with this surface material is a large number of small, round, iron concretions like those found in parts of the Miami silt loam, from which, presumably, a large part of them has been derived.

Artificial drainage has scarcely been attempted on this type, beyond leading furrows across the surface and plowing in narrow lands. Much of the soil is wet, and therefore cold, rendering it unsuited to crops like corn. Wheat is the chief crop grown, and from it the best results are obtained. Yields of from 30 to 35 bushels per acre are recorded, but in a wet season from 15 to 20 bushels would represent the average. The yields of corn, oats, and all other crops started early in the spring are generally rather low. Hay yields as much as

2 tons per acre. If in proper moisture condition the soil cultivates well.

Undoubtedly the best treatment for this type is to establish thorough underdrainage. The mechanical condition of the soil would be greatly improved, ordinary surface water would be carried away, and the land quickly dried to the proper condition as soon as the flood water subsided, thus resulting in a minimum loss of growing crops. After such treatment corn, wheat, oats, and hay could be grown more successfully. Much improvement in the productive power of the soil is possible under proper management.

The following table gives mechanical analyses of typical samples of this soil:

Mechanical analyses of Waverly clay loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10844	1¼ miles E. of Horseshoe Lake.	Heavy silty loam, 0 to 15 inches.	0.4	1.1	0.4	0.4	4.4	73.1	19.9
10727	1¼ miles E. of Moscow Mills.	Heavy silty loam, 0 to 10 inches.	1.1	2.6	.3	3.7	5.9	62.2	23.1
10845	Subsoil of 10844	Gray stiff clay, 15 to 36 inches.	.2	.8	.3	.4	3.1	60.0	35.2
10728	Subsoil of 10727	Brown sticky clay, 10 to 36 inches.	.1	.7	.6	1.6	2.3	38.5	56.2

YAZOO CLAY.

The soil of the Yazoo clay, ranging in depth from 3 to 12 inches, is a heavy black clay loam, or a heavy black clay, slightly loamy. The subsoil in most cases is a very heavy dark-drab or black clay, sometimes highly plastic and waxy, extending to a depth of several feet. When moist the soil has a tendency to be sticky and to adhere to an auger or other implement inserted in it. Because of this quality it is locally referred to as "black sticky land," and the heavier phase is sometimes also spoken of as "gumbo."

The Yazoo clay, with unimportant exceptions, is confined to the large river bottoms. Large bodies of the type occur throughout the Mississippi bottom, and as parts of islands in the main stream. Areas of considerable extent also occur in the Illinois bottom, but only a few bodies are found in the Missouri bottom. The surface of the type, though comparatively flat, is rendered uneven by many old slough ways, and in the bottoms of these sloughs, on the islands, and lighter subsoil than in the remaining areas. This subsoil is black in color and has some of the qualities of a heavy clay loam. Nearly all of this phase is covered by a mixed growth of hardwood timber. Some portions of the type in the Illinois bottom form a medium-level terrace abutting against the high land, and the surface has been somewhat dissected by stream action. In this position the soil material is of the very heaviest character, and most of it is covered by a scanty growth of gnarled black oak. In the Mississippi bottom the type forms a considerable extent of prairie covered by coarse, wiry grass and sedge.

Practically all of the type is within the flood plain and is covered with water more or less regularly. Water several inches deep stands on the surface in certain areas for a considerable time after the floods subside. This water comes both from the large streams that flow through the bottoms and from the small streams that come down from the uplands. The largest four of these low-lying areas are distributed as follows: One a mile southeast of Winfield, the second between Brevator and Old Monroe, the third extends from a mile below Cuivre River to near Peruque Creek, and the last lies south of this creek opposite St. Peters. Together these areas cover a number of square miles. South of the Mississippi River, at the extreme eastern margin of the survey, the elevation, however, is such that even the heavy floods of 1903 did not cover the areas. Near Peruque there are two large lakes, and an effort is being made to drain them. The soil in these, so far as it could be examined at the time of the survey, appeared to be a little lighter and deeper than that of the surrounding type and very rich in organic matter, and the subsoil seemed of about the same texture as the soil.

The Yazoo clay is sedimentary in origin, being formed by flood-water deposition, and the material has been accumulated from widely separated regions higher up the rivers. East of Winfield and near Peruque several thousand acres, as well as a few small areas elsewhere, are protected by levees and are cultivated. Some other areas are also under cultivation, and when water does not interfere the crop yields are large. The main drawback to the cultivation of this soil is the poor drainage. Within leveed areas surface ditches are used to remove the surplus water, and at other points in the area a few acres have been tiled. Thorough drainage would make this type the most productive in the area for several crops. Reclamation of some portions of the Yazoo clay, however, would be a rather difficult and expensive process, requiring in some places levees 10 feet high to be effective against the highest floods, as well as a complete system of both surface drainage and underdrainage. The problem of drainage will be discussed more fully in another place. Even in the swampy areas, however, large yields of hay—4 to 7 tons per acre—are secured.

This soil type is preeminently suited to wheat, which is the chief crop grown, and yields of 50 bushels per acre are reported, though the average is probably not more than 30 bushels. Corn is grown to a limited extent, and yields from 30 to 50 bushels per acre. Timothy will make from 2 to 3 tons, if not winter-killed. These yields are obtained only under good seasonal conditions and freedom from flooding. Corn and oats, especially the latter, would grow well if the ground were in proper condition at seeding time, and cabbage, onions, and sugar beets would also do well.

The following table gives the results of mechanical analyses of typical samples of the Yazoo clay:

Mechanical analyses of Yazoo clay.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct*
10973	2¼ miles NE. of Brussels.	Dark silty loam, 0 to 12 inches.	0.0	0.0	0.4	1.6	4.3	72.6	20.9
10847	1 mile E. of Brussels	Black sticky clay, 0 to 6 inches.	.6	1.3	1.0	2.5	4.6	50.2	39.7
10975	¼ mile S. of Kampville Station.	Black clay, 0 to 12 inches.	.1	.5	1.0	5.0	3.5	48.3	41.6
10848	1 mile SW. of Maple Lake.	Clay, 0 to 7 inches	.3	1.7	4.4	9.0	2.0	37.0	45.6
10974	Subsoil of 10973	Dark silty loam, 12 to 36 inches.	.0	.2	.2	1.0	3.0	78.2	17.4
10976	Subsoil of 10975	Dark heavy clay, 12 to 36 inches.	.2	.5	.4	.8	1.2	52.8	44.1
10849	Subsoil of 10848	Heavy clay, 7 to 36 inches.	.2	2.3	5.1	11.3	1.8	29.8	49.3
10846	Subsoil of 10847	Gray, stiff, heavy clay, 6 to 36 inches.	.1	.9	.7	6.6	7.2	23.3	61.2

YAZOO LOAM.

The Yazoo loam is an exceedingly variable type, and no definite general statement of the character of the soil and subsoil can be made. Over a large part of the type the soil, to a depth of from 10 to 30 inches, consists of a heavy silt or clay loam of black color, beneath which is a deep gray fine sand. The remainder of the type has a gray or dark-brown fine sandy loam from 10 to 25 inches in depth and variable within the soil section. This rests on a roughly stratified dark heavy loam, which changes to a fine sand at a depth of several feet. The sandier top soil occurs on the banks of the streams or along some main channel, and is most abundant in the Missouri bottom. In many places the variations from the light to the heavy material occur within such short distances that it is impossible to separate them on the map.

The type is confined to the bottoms of the Mississippi and Missouri rivers, adjacent to the main streams, and forms the greater part of a number of large islands. In all it has an extent of several square miles.

The surface is low and comparatively flat, but it is much cut up by many small abandoned stream courses. These courses lie generally parallel to each other and form inequalities that are a serious hindrance to cultivation. Greens Bottom and the large bottom southwest of it on the Missouri River are the highest and most level portions of the type, and the rich loam forming them is under a high state of cultivation. The common variation consists in the occurrence of heavy loam in the old stream courses and light sandy loam on the low ridges forming their banks. The phase having a heavy top soil is the more prevalent. Most of the islands are very low and are covered with hardwood timber.

The drainage of the depressions is poor, while that of the ridges is good except during floods. Standing water is of common occurrence in the depressions.

The material forming the Yazoo loam is the most recent deposit of the rivers, and is being added to during every overflow. The fine sand is the deposit from the swiftest currents, and is usually found where the water leaves the main channel. Deposits 2 feet in depth were laid down by the high water of 1903. The basal sand was first deposited as sandbars, and the heavy loam was laid down by slow-moving currents after the surface had been raised considerably above the medium water level. In the Missouri bottom the meanderings of the stream are effecting a rearrangement of much of this type by cutting away at one point and redepositing at another. In this way several hundred acres of valuable land of this character have been destroyed, while the new land formed will not be suitable for cultivation for a number of years.

Nearly all of the mainland part of the type in the Missouri bottoms and considerable areas on some of the islands are cultivated and produce large yields of corn, oats, and wheat. Along the Mississippi some cultivation is practiced, corn being almost exclusively the crop. Damage by floods is a constant menace. Corn yields from 50 to 100 bushels and oats from 40 to 50 bushels per acre. Along the Missouri River wheat yields have reached 30 and 35 bushels per acre, but this crop has a greater tendency to lodge than on the heavier soils. In the areas along the Missouri some orchard and small fruits are grown

with good results. On the medium heavy areas p
200 to 250 bushels to the acre.

On the whole the conditions of the Yazoo loam
is the safest and most profitable crop, although pot
a variety of late and medium late truck crops and
be produced with success. Crops maturing in a si
be preferred on this soil. In general its working
and the frequent inundations render fertilizers un

The following table gives mechanical analyses of
the Yazoo loam:

Mechanical analyses of Yazoo loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to
			P.ct.	*P.ct.*	*P.c*
10979	1 mile N. of Mona ...	Gray loam, 0 to 13 inches.	0.0	0.0	0.
10977	1 mile S. of Millers ..	Dark clay loam, 0 to 20 inches.	.0	.0	Tr
10978	Subsoil of 10977	Fine sandy and silty loam, 20 to 36 inches.	.0	.0	.
10980	Subsoil of 10979	Dark silty clay, 13 to 36 inches.	.0	.1	.

MIAMI FINE SAND.

The Miami fine sand is a dark-gray or brown fin
12 inches deep and sometimes rather heavy, under
brown fine sand.

The type forms a narrow strip at Deerplain,
position of a terrace 20 or 30 feet above the adja
and occupies, besides, several small areas in expose
Missouri bottom. Its surface is gently rolling, a
lowy where the wind has been active in the move
Except during floods the type is well drained, a
quickly affected by dry weather.

The elevated portions were probably formed by t
when it flowed at a much higher level than at pres
ing low-lying parts are the result of very recent de
prise such bodies of light sand associated with the
large enough to be shown on the map.

Probably two-thirds of the type is cultivated to
Its productive power is low. Corn yields only fro
per acre and wheat in proportion. Strawberries

fruits and truck are grown, with fair results, near Deerplain. At that point apples are also being tried, but marked success should not be expected on so light a soil in that position. When well manured and carefully cultivated it is an excellent soil for early truck, strawberries, and melons.

The following table gives mechanical analyses of typical samples of this soil:

Mechanical analyses of Miami fine sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10834	½ mile S. of Deerplain, Ill.	Fine sand, 0 to 12 inches..	0.0	2.4	14.4	69.9	4.6	5.8	2.9
10835	Subsoil of 10834	Fine sand, 12 to 36 inches.	.2	2.3	15.4	72.3	3.6	3.4	2.7

SIOUX SANDY LOAM.

The soil of the Sioux sandy loam, to a depth of from 20 to 25 inches, is a black or dark-brown sandy loam, composed of silt, sand, clay, and a low percentage of fine gravel. It grades downward into an iron-stained, waterworn gravel, in which the bowlders seldom exceed 2 inches in diameter. These gravel beds are several feet in depth, roughly stratified, and composed largely of fine gravel.

This type is less than a square mile in extent. It forms a low bar removed a short distance from the bluff at Brevator, includes fragments of an ancient river terrace at Old Monroe, and appears at a couple of points between Brevator and Winfield. The surface is gently rolling, having an easy slope, and the basal gravel was evidently deposited by swift local currents and later covered by the sandy surface material. The drainage is good and the type is not subject to overflow.

A maximum yield of from 70 to 80 bushels of corn and from 30 to 40 bushels of wheat, per acre, are produced on the area at Brevator, and large yields of good potatoes have been obtained. The yield of all crops is large in moist seasons, but dry weather affects growing plants in a short time.

In addition to corn and potatoes the type is well adapted to melons, medium truck crops, and small fruit.

The following table gives mechanical analyses o
ical samples of this soil:

Mechanical analyses of Sioux sandy lo

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to
			P. ct.	*P. ct.*	*P.*
10840	¼ mile E. of Brevator.	Black sandy loam, 0 to 20 inches.	9.0	39.3	12
10841	Subsoil of 10840	Brown sand and gravel, 20 to 36 inches.	32.5	47.2	10

DRAINAGE.

Throughout the 165 square miles of bottom la
rivers the factors that most largely govern cro
year to year are the drainage of the soil at time
level in the streams and the protection of the cro
at times of high water. On the uplands, also, co
the heavier phase of the Marion silt loam would
by the use of tile drains, even where there is a co
the surface of the fields. At ordinary times th
aerate the soil and to put it in such physical co
excessive rains occurred more of the water could
injurious effects and the surplus quickly carried
to growing crops resulted. Winter heaving of
would then be less severe, and leguminous crops co
more successfully than under present conditions.

In the bottoms two methods of improvement,
some degree, are practicable, but the best results
a combination of levees with surface drainage a
In the past there has been a lack of concerted acti
on the part of the small farmers, and not enough
control to accomplish much, except in two compar

A 5-foot levee has been built around several
Winfield, mostly outside the limits of the prese
it was observed this levee ranges in height from
effective in most seasons, though it was overtoppe
high water of 1903. South of it, and extending do
the Cuivre River, is a large body of land, at prese
vated, a superficial examination of which indicates

in height would be a sufficient protection. In this area, however, the flow of several small streams would have to be cared for.

Near Peruque 3,000 acres are under a levee constructed in 1896, which has been an adequate protection every year save one since that time. In one season the 2,500 acres seeded to wheat yielded 94,000 bushels, or an average of 37 bushels to the acre. This is the best yield that has been obtained.

It is, of course, possible to levee all the bottoms, and although in some instances the probable returns under present conditions would hardly warrant the necessary expenditure, nearly all of the Mississippi bottom, it is believed, could be protected and fair returns on the investment obtained.

The common method of drainage is by the use of surface ditches and by plowing in narrow lands. Where open ditches are constructed along every quarter-section line they are a considerable hindrance to cultivation and a permanent expense for maintenance. Besides, at this interval, they are not sufficiently effective, and drain furrows are necessary. This system is practiced within the levee near Peruque, and large reservoirs are constructed at the lowest point within the inclosure, the dirt excavated being used in the construction of the levee. At this point a pumping station is maintained to handle the surface water during the periods of flood, when the drainage system is not effective beyond the levee. It is now planned to have the reservoirs large enough to hold nearly all of the surface water at such times.

At other points tile drainage is in use and is said to be effective, the drains remaining in good condition. If this be true, large open main ditches, with tile drains as laterals, would be the ideal system. It is claimed by certain practical men that the clay subsoil is too heavy for tile drains to be permanently effective. In any event, they should be constructed with a large fall, because large amounts of silt must be moved at times. Silt wells and protected inlets should be used.

Even if flooding were not prevented by a levee, a complete system of drains would be a great help. The high water seldom continues for many days, and as soon as it had subsided the land would be quickly dried to a cultivable condition. The general working properties and the moisture-holding power of all the heavier soils would be greatly improved by such treatment.

AGRICULTURAL METHODS.

In the O'Fallon area the average depth of plowing is from 4 to 6 inches, and the common practice in cultivation is to use large-shovel, deep-running implements and to leave the crop on a ridge at the end of the season. This method should be abandoned on all types of soil. Except perhaps on some of the deep black loam, upland prairie soil, and on the Waverly silt loam the depth of plowing should be gradually increased to from 7 to 10 inches, with proper packing of the under part of the furrow slice. This will give a much greater area for the extension of the plant roots and render the crop less susceptible to slight seasonal variations. Furthermore, the cultivation of all crops should be made as level as possible by the use of small-shovel cultivators, and weeders where effective, run to a depth not exceeding 3 inches, and the operation should be repeated about twice as often as under the present system. Effort should be made to maintain a good shallow mulch and to avoid pruning off the feeding and supporting roots of the growing plant. This method of plowing and cultivating is essential to successful crop production under any but the most unusual conditions and can not be too strongly impressed on the mind of the farmer. This practice has been adopted by a few farmers in the area surveyed, with most profitable results, and the general need for such a system is strongly emphasized by the great difference in the returns from different farms of the same size and same character of soils.

The value of barnyard manure is recognized, and it is used chiefly on corn land. Commercial fertilizers are used on wheat in amounts usually less than 200 pounds to the acre, and profitable results are obtained.

Grain and hay are the chief crops. As has been indicated, wheat is about the only crop produced on some of the heavy bottom soils, and is also considered best suited to the heavy uplands. Large amounts of corn and oats are also grown. The rotation generally practiced on the uplands is pasture or meadow land plowed for corn, to which the barnyard manure is applied, followed by wheat or oats, then wheat seeded to timothy in the fall and clover added in the early spring. Hay and pasture usually occupy the land for two years. In recent years there has been much difficulty in securing stands of grass in this manner, and the rotation has undergone some change.

Cattle and hogs are kept in considerable numbers and consume most of the corn, oats, and hay. Silage is used very little. A larger variety of leguminous crops should be tried and more care exercised in their seeding and management. It is believed that on the uplands less wheat and more forage should be grown. Alfalfa and cowpeas should succeed on all the lighter areas of the Miami silt loam, and, with good drainage established, on the heavier areas also. They will do well on the Memphis silt loam and the Waverly silt loam.

The farming class, as a rule, is fairly prosperous. The farms range in size from less than a hundred up to several hundred acres. The following statements regarding conditions are based largely on the figures of the Twelfth Census for St. Charles County. So large a part of that county is included in the area surveyed, and the general conditions in the adjacent counties are so similar, that the figures may be accepted as representative of the area.

Nearly 75 per cent of the land is improved, and the average value per acre is $35. From $30 to $60 is about the range of prices for good general farming land with fair buildings. The average size of farms is 130.7 acres, and the average value of buildings per farm is $1,154. The farmhouses as a rule are not large or expensive, but are substantial and comfortable. Most of the barns and other outbuildings are small. The average value of farm machinery is $220 per farm, and that of domestic animals is $615.

The people are a thrifty and very conservative class, who do not quickly change their methods of farming. This makes for stability. if not always for the greatest success. Too little regard is given to agricultural literature. In St. Charles County 44.9 per cent of the farms are operated by the owners, and renting is practiced to a very considerable extent. Both the crop and cash rent systems are in vogue. On the best land the owner prefers a grain rental of from two-fifths to one-half of the crop in marketable condition. Cash rents range from $2 to $4 an acre.

The leading crops of the area, in the order of their importance, are wheat, corn, hay, oats, and potatoes. The average yields for the whole area are wheat, 14 bushels; corn, 33 bushels; hay, 1¼ tons; and potatoes, 100 bushels to the acre.

The value of live stock fed and sold for meat is large, but satisfactory figures are not available. Wentzville and Troy are important shipping points for stock. Around Wentzville and Winfield considerable dairying is practiced, and there is a creamery at New Melle. In the region around Wentzville the value of the poultry and eggs produced is many hundred dollars annually.

Fruit growing is receiving much more attention than formerly, particularly on the points of highland between the large rivers in the eastern part of the area. Apples are much in the lead in acreage and value, the orchards covering several thousand acres. In the Illinois part a rough estimate of their extent would be between 3,000 and 4,000 acres, of which half or more has been planted within the last two years. At several points in the Mississippi bottom large plantings of apple trees have lately been made, and some small orchards are in bearing. These plantings have been made on the

Waverly clay loam and Yazoo clay. It is questionable whether these will be a commercial success. On the uplands the industry has a substantial, practical, and profitable basis. In Illinois the fruit is sold on the trees to outside buyers and is shipped to market by way of the river. Peaches, which could be successfully produced, are not grown because of the inconvenient shipping facilities. The varieties of apples most planted are the Ben Davis, Jonathan, Janette, and Willow Twig. Very little attention is given to the production of small fruits and truck.

There is a general recognition of the adaptation of crops to soils, as has been indicated in the discussions of the various soil types, but this adaptation is by no means always considered in planning the crop rotations or in deciding upon the crop to be grown.

While the general conditions in the area are good, there is much opportunity for improvement along the lines of better drainage, deeper plowing, and more shallow and frequent tillage, larger production of leguminous forage, more live stock on the uplands, and more careful attention to manuring and to the maintenance of the crop-producing power through rotation and other means. The value of farm land in every section of the area would be greatly increased by improving the country roads, nearly all of which are unsurfaced. By placing a stone crusher in each township and applying crushed limestone, which is found in all of the hills, excellent roads could be maintained. There are large sections in the area at a considerable distance from shipping points, and the construction of better roads would remove one of the difficulties in the way of further agricultural development.

SOIL SURVEY OF WEBSTER COUNTY, MISSOURI.

By J. A. DRAKE and A. T. STRAHORN.[a]

LOCATION AND BOUNDARIES OF THE AREA.

Situated in southern Missouri, a little west of the center, Webster County includes within its boundaries about 605 square miles of the most elevated portion of the Ozark uplift or plateau. It is nearly rectangular in shape, with the extreme dimensions 28½ miles long by 22 miles wide, and lies about 50 miles from the Arkansas and about 90 miles from the Kansas line. It is situated along the main line of the St. Louis and San Francisco Railroad, over which it has direct connection with St. Louis, distant about 200 miles, and over the Kansas City, Fort Scott and Memphis branch of the same road with Kansas City, about 225 miles away. Springfield, the junction of these two lines, is situated about 20 miles west in an adjoining county.

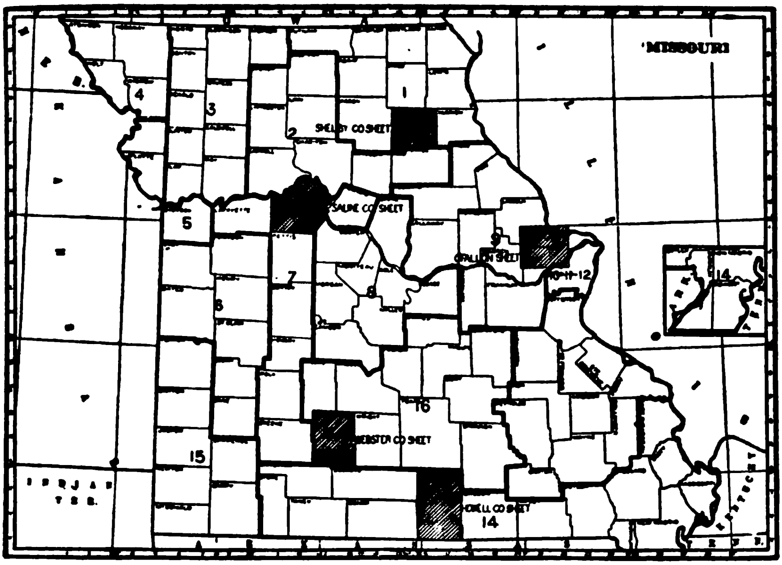

FIG. 35.—Sketch map showing location of the Webster County area, Missouri.

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[a] During a part of the time Messrs. Charles W. Ely and Frank Bennett assisted in the prosecution of the field work.

Within the area are no large towns. Marshfield, the county seat, has a population of 1,200. Seymour, Niangua, and Fordland are smaller but thriving railroad towns. Away from the railroad only small villages and country cross-roads stores are found.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The first white settlers came to what is now Webster County about 1834, mainly from Kentucky and Tennessee. A large movement from these States soon followed, which afforded this portion of Missouri its pioneers and contributed much to its growth. At this time it was not the agricultural value of the country which attracted the settlers so much as the advantages which it afforded as a hunting ground and as a region where stock raising could flourish with little effort. Game and fish were abundant, and everywhere there was a luxuriant growth of the native blue stem grass, on which cattle thrived the year round. Hogs were raised and fattened on nuts alone. There was no necessity, therefore, of growing much grain, and accordingly it became the custom to settle near a spring, regardless of the adaptability of the surrounding land for this purpose. The little grain needed was grown along the bottoms of the small streams or in the draws. In this way many of these earlier settlers came into possession of what in future years proved to be the poorer farms of the area.

It was not until 1855, and under some of the conditions described, that the county was organized. The growth in population is shown to have been rather slow, as the increase was only a little over 1,000 during the fifteen years from 1856 to 1870. In 1870 the main line of the St. Louis and San Francisco Railroad was completed, since which time the growth has been more rapid.

About 1870 the native grass, which had been an important factor in the agriculture of the county, began to disappear, and the conditions to change quite generally. Prior to this it had been the custom to burn over the pasture fields and woodlands every spring, but as the country became more thickly settled and more or less fenced this custom had to be abandoned, and a thick growth of underbrush, which had been kept down by the annual fires, sprang up in the open and more timbered fields and choked out the grass, while settlement and cultivation were already beginning to reduce the acreage of the natural range to a marked degree. These changes brought about an increased acreage of grain and other cultivated crops. This system of farming embracing only a few crops, corn being the most important, has continued with but little change up to the present time.

In 1892 some large apple orchards were set out in the vicinity of Seymour, in the southern part of the county, but fruit received comparatively little attention throughout the county until 1901, when there occurred a season especially suited to the production of an extra good apple crop. Farm crops were quite generally a failure, owing to drought, and the farmers found the small orchards planted for their own private use a source of no small income. This led to an increased interest in apple culture, and the acreage in orchards was extended in nearly every part of the county. As a result, the orchard of from 500 to 2,000 and 3,000 trees, two and three years old, is very common. Since the big crop of 1901, however, the fruit crop has been almost a failure, and at present very few orchards are being set out.

CLIMATE.

The climate of Webster County is rather mild. The heat of the summers is not, as a rule, oppressive, and the winters are quite generally open, being made up of alternating periods of mild and moderately cold weather. The thermometer does not often record a temperature below zero, and a rise in temperature generally follows immediately. What little snow falls is quickly melted. The warm periods are very often sufficient to start the fruit buds early in February, in which case they are almost invariably killed by later freezes. Probably this constitutes the most serious hindrance to the fruit-growing industry in the area and is responsible for most of the failures. An occasional dry spring is quite favorable to the fruit crop, other conditions being equally so. Short periods of drought occur, but are not common to any particular season of the year. With this exception the precipitation is well distributed throughout the year, as is shown by the accompanying table, compiled from records of the Weather Bureau.

Normal monthly and annual temperature and precipitation.

Month.	Springfield.		Seymour.		Month.	Springfield.		Seymour.	
	Temperature.	Precipitation.	Temperature.	Precipitation.		Temperature.	Precipitation.	Temperature.	Precipitation.
	° F.	*Inches.*	*° F.*	*Inches.*		*° F.*	*Inches.*	*° F.*	*Inches.*
January	32.3	2.48	34.2	2.81	August	74.0	3.65	75.7	3.74
February	34.7	3.15	30.6	2.52	September	67.7	3.76	67.8	3.36
March	43.5	3.72	43.6	4.75	October	56.0	3.06	58.5	3.45
April	57.5	3.84	55.3	4.15	November	43.5	3.11	44.9	3.10
May	63.2	5.97	65.6	5.67	December	38.6	2.64	33.9	2.24
June	72.4	4.46	71.7	4.39	Year	54.9	44.17	54.8	43.47
July	75.7	4.33	76.2	3.29					

Seymour is situated in the southeastern part of the county and Springfield in Greene County, the next adjoining county on the west. The frost records of these same stations show the average date of last killing frost in spring to be April 13 at Springfield and April 15 at Seymour, and the first in fall October 30 at both staions.

PHYSIOGRAPHY AND GEOLOGY.

The topographic features of Webster County, though somewhat varied, show a marked similarity throughout. The greater portion of the county has been subjected to severe erosion, which has caused many changes in the once comparatively level surface of the elevated plateau. Considerable differences of elevation have thus resulted and a series of stream channels cut out, which, with their smaller tributaries, have divided the surface into irregular ridges and undulating table-lands. These are sometimes separated by narrow strips of bottom land or merely in other cases by the streams or draws themselves.

Occurring as it does in the most elevated portion of the Ozark Uplift, Webster County forms a part of the main divide between the tributaries of the Missouri River on the north and those of the Arkansas on the south. Of the former, the Osage River branch of the Gasconade and the two branches of the Niangua have their sources near the center of the county and leave its borders on the north, while the Pomme de Terre rises about 2 miles west of Marshfield and flows out of the county to the west. Of the latter the James Fork of White River is the most important., It is formed by the junction of a few small streams a short distance northeast of Seymour, and taking a generally western course leaves the county about 7 miles south of the center. Findlay Creek, a tributary of the James Fork, together with Beaver Creek, has its source in the extreme southern part.

The dividing ridge between these two drainage systems may be traced from the western line of the county along the main line of the St. Louis and San Francisco Railroad to the vicinity of Marshfield; thence it takes an irregular southeastern course to the vicinity of Seymour, and is followed by the Springfield and Memphis branch of the same system out of the county. From this divide another one extends northeast between the Osage branch of the Gasconade and the Niangua rivers, another northwest between the Niangua and the Pomme de Terre, while still another lies to the west of Seymour between the James River and Findlay Creek. This makes up the topographic outlines of the area, but these main ridges are cut by the tributaries of the more important streams into innumerable ridges of varying widths, the slopes of which are either precipitous and deeply gullied by draws or descend with a gentle and graceful curve to the stream below. In the vicinity of the larger streams the topography is generally rugged and more broken, and the ridges between the tributary streams often end in a precipitous bluff 50 to

200 feet high. Back from the bluff lines the country generally becomes less deeply cut, with more gentle slopes, and finally merging in many cases in a gently rolling table-land on the crest of the main divide. The most notable instances of this occur about Seymour and west and northwest of Marshfield, while minor areas of this sort are of frequent occurrence throughout the county. These table-lands are occupied by the Clarksville silt loam, the surface of which is generally free from stone; but as the streams are approached the predominating type is the Clarksville stony loam, unless on an occasional long and gentle slope, where the silt loam covers the greater area. On the accompanying map the streams are put in in some detail, as they bear an important relation to the soils. The smaller ones, however, are often mere draws or small ravines in which there is no water except when it rains, but a great many like the larger streams are perennial, being fed by springs, in which the area abounds.

The greatest elevation of the main divide is southeast of Seymour, where the surface rises to 1,654 feet above sea level. Along this ridge there is a gradual decline to the westward to 1,457 feet at Northview. The general elevation of the county is found between these figures. This is about the maximum elevation in the State. Taken in connection with the great number of ramifying streams the elevation and rolling or hilly surface afford ideal drainage conditions throughout the entire area.

The geological formations that give rise to the soils are of sedimentary origin, belonging to the Lower Carboniferous and Devonian limestone series, of which the St. Louis limestone is the most prominent. Below this lies a bed of coarse-textured shale, with interbedded layers of limestone, probably of Devonian age. The latter formation is present in nearly all parts of the area, but varies somewhat in thickness. In places it has been weathered away. West of Marshfield a cut exposes a thickness of about 15 feet, and then does not reach to the base of the formation. Below the shale is a massive formation of sandstone, generally white, and of medium fine texture, which outcrops in the bottoms of many streams, but affects the soils of the area comparatively little. It is most prominent about Marshfield, where its effects on the soil are marked, giving rise to a few small areas of fine sandy loam.

None of the soil types as found in the area can be said to be derived from any one of these formations exclusively, as occasionally all contribute more or less material. In a general way, however, the first-named formation is the most important in the formation of the Clarksville stony loam and is largely responsible for the Clarksville silt loam on the higher ridges. In the vicinity of Marshfield and northwest of that place the shale has contributed more or less to the latter type. In the case of the sandy loam much of the material has been derived from the upper formations, but the sandstone is responsible for its sand content.

SOILS.

The soil map accompanying this report shows in colors six different soils. Two of these, Rough stony land and Riverwash, are of so little value as to be practically nonagricultural; the other types have already been established in earlier surveys, having been found first in the survey made around Clarksville, Tenn.

The Clarksville stony loam and Clarksville silt loam also occur in Howell County, Mo.

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Clarksville stony loam	212,992	55.1	Rough stony land	3,200	0.8
Clarksville silt loam	147,712	38.2	Riverwash	1,856	.5
Clarksville loam	17,600	4.5	Total	386,944	
Dekalb fine sandy loam	3,584	.9			

CLARKSVILLE SILT LOAM.

The Clarksville silt loam is the second soil in extent in the area. The surface soil is a yellowish-gray silt loam with an average depth of 10 inches. Below this, to a depth of 36 inches, the material is a heavy compact silt loam to silty clay, and there is a decided change in color, which becomes yellowish brown mottled with gray. There is a marked deficiency in organic matter throughout the type. Even in the woodlands the proportion is very small and confined to the upper 2 or 3 inches, and this disappears after a few years of cultivation. Unlike most soils of this texture, low in organic matter, it does not become compact and hard, but remains loose and friable under most unfavorable conditions. The surface is quite free from stones, excepting small patches, and rock fragments are only occasionally encountered in the subsoil, usually at from 25 to 32 inches below the surface. It has an excellent water-holding capacity and responds more readily to applications of manure and the rotation of crops with clover than any of the other soils of the area.

In many instances, where it is apparent that this soil and the Clarksville stony loam are derived from much the same formations, this freedom from stone on the surface and in the subsoil seems to be the chief difference between the two. But this in itself gives rise to other differences of importance. The rock fragments of the Clarksville stony loam render its soil and subsoil more open, and consequently it is less able to withstand drought, while on the other hand the Clarksville silt loam is more subject to the effect of prolonged wet weather. The silt loam is thought by many to be more easily reduced in productiveness by continued farming than the stony loam, which is probably true.

The Clarksville silt loam is quite well distributed throughout the area. It occurs on undulating ridges, in somewhat rolling table-lands, and on long and gentle slopes. The most important areas occur about Marshfield, west and northwest from that place toward Elkland, and in the vicinity of Seymour. These areas mark parts of the country very desirable for general agriculture. The elevation and topography are such as to provide good surface drainage, while at the same time the type as a whole suffers little from erosion.

The materials forming this soil are derived from the weathering of limestone and shale. On the broader ridges and more level uplands the soil left by this process has remained undisturbed by running water and is of good depth, but on the narrower ridges and steeper slopes conditions have been the reverse and a thinner covering is found.

The soil seems to be especially adapted to wheat and clover, but other crops do well. It is probably not so well suited to orcharding as the Clarksville stony loam. The average yield per acre of wheat ranges from 10 to 12 bushels, of corn 18 to 25, and hay (clover and timothy mixed) from 1 to 1½ tons. These yields are low as compared with the possibilities of this soil under better management. As previously stated, the organic-matter content is very low; and only in proportion as this is increased and as a more systematic rotation of crops and better cultivation are practiced can this type be expected to yield better returns. The plowing under of clover and cowpeas, both of which grow very satisfactorily, is imperative, while all other roughage similarly treated can but be beneficial.

The following table shows the texture of typical samples of the soil and subsoil of this type:

Mechanical analyses of Clarksville silt loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12370	1¼ miles E. of Rogersville.	Gray silty loam, 0 to 10 inches.	0.6	2.1	1.1	2.0	4.7	69.8	19.7
11895	1¼ miles W. of Marshfield.	Gray silty loam, 0 to 10 inches.	.9	3.0	1.3	2.2	1.6	67.7	22.8
12371	Subsoil of 12370	Silty clay, 10 to 36 inches.	.5	1.0	.6	1.2	3.4	59.7	33.4
11896	Subsoil of 11895	Brown silty clay, 10 to 36 inches.	.8	1.6	.6	1.6	1.3	58.1	35.6

The Clarksville stony loam prevails over much the greater part of Webster County. The surface 9 inches consists of from 20 to 50 per cent of rough angular rock fragments, largely chert, but in some instances mingled with sandstone and magnesian limestone embedded in the residue of their decay. The soil is of a light-gray color, with here and there a slight yellowish tinge, and has a peculiar silty texture. The clay content gradually becomes greater and the color darker with depth until at 25 inches it is a red clay, usually containing less rock fragments than the soil, although an equal quantity is not uncommon.

The rock fragments in this soil and on its surface have the effect of preventing packing or baking, which effect is especially desirable in orcharding. They also retard washing, though, on account of the open porous condition thus produced, crops quite generally suffer more from a lack of moisture on this type than on the others in the area.

The Clarksville stony loam is found in all parts of the area, occupying the narrower ridges and their slopes. It occurs, also, on rounded eminences that have been protected by the rocks from erosion. On the whole the topography is uneven, broken, and often rugged. The drainage is excellent.

The Clarksville stony loam is formed by the weathering and breaking down of various rock formations. Chief among these is a very cherty limestone, which, on account of its great resistance, remains in fragments scattered through the soil, the proportion being less in the more level areas and greater on the slopes, where more of the soil has been removed by wash.

The number of farm crops grown on this soil is limited and the yields moderate, varying much with the season. Corn ranges from 15 to 30 bushels, wheat from 8 to 10 bushels, and hay (clover and timothy) from 1 to 1¼ tons per acre. Oats are very little grown, but yields varying from 15 to 30 bushels have been produced. Cowpeas give fairly good yields during an average season. The soil shows the same deficiency in organic matter as the Clarksville silt loam, and this is doubtless largely responsible for the low yields. It should receive the same treatment recommended for the Clarksville silt loam.

The Clarksville stony loam is believed to be the best fruit soil of southern Missouri, and it is largely this type that has won for this section of the State its reputation as a fruit-growing district. Its adaptation in different parts of the area to apples, peaches, pears, plums, small fruits, and grapes has been proved beyond question. Local climatic conditions may be more favorable to one or another of these fruits, but taken as a whole the apple probably does best in this

area. In good seasons an abundance of fruit of an exc
quality, and flavor is produced.

The following table gives the results of mechanical an
fine earth of the soil and subsoil of this type:

Mechanical analyses of Clarksville stony loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*
12376	¼ mile E. of Northview.	Gray silty loam, 0 to 10 inches.	2.6	3.3	1.3	3.2
12374	2¼ miles E. of Fordland.	Gray stony silty loam, 0 to 10 inches.	2.1	1.9	.8	1.7
12377	Subsoil of 12376	Red silty clay, 10 to 36 inches.	1.9	2.3	.8	2.9
12375	Subsoil of 12374	Brown stony clay, 10 to 36 inches.	1.6	2.3	.8	1.8

CLARKSVILLE LOAM.

The soil of the Clarksville loam consists of a dark-
loam, with an average depth of 12 inches, the organi
which is materially higher than in the upland types.
tion of sand, which is fine in texture, occasionally be
noticeable in the ordinary field examination, but the gre
the area is a typical silt loam. The remainder of the
inches is a brown silty loam slightly heavier than the
but of about the same character of material. This is es
in the broader and better defined valleys of the larger st
the type is almost entirely alluvial. Where it is found
strips along the smaller streams the subsoil contains
gravel and the surface soil is often thin.

The type is well distributed throughout the area,
extensive along the Osage Fork of Gasconade River. I
and in the rest of the broader ones it occurs as a well-de
land which has a level topography. While subject here
sional overflow, which generally does little damage to
ample drainage. In the upper and narrower valleys it
a slight slope to the stream, which affords a surface drai
better than in the larger areas.

In the process of formation the material of the Clar
has been largely derived from wash from the uplands
Where it occurs along the more important streams the

been carried down and deposited in times of overflow. It is preeminently the corn and grass soil of the area. The average yield of the former ranges from 40 to 50 bushels per acre, while as high as 75 and 80 bushels have been obtained. Hay yields from 1½ to 2 tons, and occasionally even 2½ tons, per acre. As pasture, 1 acre is equal to from 3 to 5 acres in the uplands, according to the season. This, together with its ability to produce corn, has induced the farmers owning much bottom land to keep more stock, which contributes in no small measure to their success. Unless it has been under cultivation many years, this type is not well suited to the production of wheat, which grows too rank and lodges. The yield ranges from 14 to 20 bushels per acre. Small fruits do well, but are little grown in the area. Orchards make an excellent growth and are thought to be longer lived than on the uplands, but the fruit is more likely to be injured by frost. Tomatoes thrive best on this soil and have been known to yield as many as 300 bushels per acre.

The following table gives the results of mechanical analyses of the Clarksville loam:

Mechanical analyses of Clarksville loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12364	2 miles SW. of Northview.	Brown silty loam, 0 to 12 inches.	0.0	0.3	0.2	1.3	4.3	84.4	9.5
12366	6 miles NE. of Elkland.	Silty loam, 0 to 14 inches.	.1	.5	1.1	10.7	4.7	65.3	17.5
12365	Subsoil of 12364	Brown silty loam, 12 to 36 inches.	.0	.2	.2	1.4	3.1	83.4	11.5
12367	Subsoil of 12366	Brown silty loam, 14 to 36 inches.	.2	.4	.9	9.1	5.2	64.8	19.5

DEKALB FINE SANDY LOAM.

The soil of the least importance is the Dekalb fine sandy loam, which is confined to a few small areas. It consists of a light to yellowish gray fine sandy loam 9 inches in depth, underlain by a yellow or yellowish-brown fine sandy loam, the clay content of which increases materially in the lower part of the profile. Although, like the other upland soils of the area, it is quite deficient in organic matter, it is loose and friable and easily kept in good tilth.

This type of soil is found north, west, and east of Marshfield, where the thick and massive sandstone formation that underlies the other formations entering into the soils of the area comes to the surface. The soil occurs generally on gentle slopes where erosion has exposed the sandstone, and all areas have excellent drainage.

A large part of the type is not under cultivation. The remainder produces all the ordinary crops of the area. It is more especially adapted to peaches, truck, sweet potatoes, and other crops adapted to a light-textured soil, but has no special importance owing to its small extent.

The following table gives the results of mechanical analyses of typical samples of the Dekalb fine sandy loam:

Mechanical analyses of Dekalb fine sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12378	6¼ miles NW. of Marshfield.	Fine sandy loam, 0 to 9 inches.	0.3	0.5	6.7	46.7	5.0	32.6	8.0
12379	Subsoil of 12378	Yellow heavy fine sandy loam, 9 to 36 inches.	.4	.6	5.1	35.4	3.9	34.6	20.1

ROUGH STONY LAND.

Occurring along some of the streams and the deeper and more important draws are found areas too steep and stony for successful cultivation, even in orchard. The great part of the soil has been washed away and has left the surface very rough. These have been mapped as Rough stony land. The stones are usually so large as to make plowing impracticable, even if the slope were not too steep. Most of the areas are in timber and afford but little pasture, but many could be cleared without danger of great damage by washing until the grass could get a foothold, and would in a few years afford fairly good grazing.

RIVERWASH.

There occurs along many of the streams a strip varying from 8 to 30 rods in width which is composed principally of gravel, rounded rocks, and sand. Such areas have been classified as Riverwash. They are, on the whole, subject to annual change and are cut by meandering stream channels. In its typical form the soil has no agricultural value. It is present along almost all the streams to some extent, but usually the areas are too narrow to be shown on a map of the scale used in this survey.

Although the wealth of Webster County is almost entirely agricultural, its agricultural resources have not nearly attained the development of which they are capable. Of the 386,944 acres, the total area, about 275,000 acres are in farms, of which about 150,000 acres are classed as improved, the remainder being uncleared or otherwise unsuited to cultivation. Except in the case of a comparatively few farmers here and there, the practices are not the most modern or businesslike, and there is much about the average farm premises to indicate a condition none too prosperous, although, on the whole, the financial condition of the farmers is gradually becoming better. Formerly about 40 per cent of the farms were mortgaged, but the number encumbered has been greatly reduced, even under the prevailing rather unsystematic production of grain and live stock. In the hope of further bettering their condition most of the farmers have taken up the growing of apples, the success of which remains to be seen.

At present, owing to a few years of failures, the setting of orchards has been discontinued, and the industry hangs in the balance. A few good crops would serve to increase the already large acreage in orchards and to establish it firmly in this part of the State, while a few more failures would probably cause many of the present orchards to be neglected and the lands put to other uses.

Whatever doubt there may be as to the adaptability of the soil and climate of Webster County to the production of apples, there is none whatever as to the opportunity for profitable stock raising. The short mild winters, the shelter of timber and draws, the suitable soils for the production of corn, forage, and grasses of all kinds, and the abundant supply of living water all combine to make this an ideal region for raising farm animals. There seems to be no reason why the average farmer should not find this branch of agriculture a source of certain income from year to year, with the returns greater in the end than in the case of fruit growing. It is doubtful whether the average farmer can afford to give up his best farming land to orchards, or to give his orchards sufficient time and attention to insure the best success, and he will find stock raising, which is more easily within his reach, an industry to which his farm is equally well if not better adapted. Those who have ample land, however, will doubtless find that, by ordinary care, the rougher ridges and stony slopes less suited to cultivation will, if planted to orchards, yield an occasional profitable crop of fruit, which can be handled without interfering with the general farming operations.

The price of land varies from $6 to $50 per acre, depending on the character of the soil, state of improvements, and distance from town.

From $9 to $14 an acre is about the average price of farm land partly under cultivation and with ordinary improvements. While, owing to the cheapness of land in general, there are some very large tracts, the average farm contains only about 105 acres. Of the whole number of farms 35 in every 100 are rented, the remainder being operated by the owners and the members of their families. The farmers expend little for labor, and where it becomes necessary to hire there is no such difficulty in securing help as is experienced in many other States or in other parts of Missouri.

Corn, wheat, and hay are the principal farm crops, ranking in importance in the order named. The average yield per acre of corn is about 20 bushels, of wheat about 10 bushels, and of hay from 1 to 1½ tons. Oats are not grown extensively, but from 20 to 25 bushels per acre is a fair average yield. Potatoes yield from 50 to 90 bushels per acre, depending upon the season and the type of soil. While there is a large acreage in orchard in the county, many of the trees have not reached the bearing age and the production is comparatively small. There are four creameries in the county, which, together with several private dairies, are estimated to produce from $100,000 to $125,000 worth of butter and cream annually. Conditions are especially favorable for the profitable development of this industry. With the exception of the one matter of shipping facilities, most excellent locations for dairy farms are available throughout the greater part of the county, and there is probably no branch of agriculture that will prove a more paying investment for the area than this one.

The growing of tomatoes for canning purposes has been introduced lately and is rapidly assuming importance as an industry. The soils are well suited to this crop, producing tomatoes of large size and excellent quality, while the lateness of frosts in the fall in this section permits them to grow and ripen through a much longer period than in more northern areas. There are four canning factories in the county at present, and through the influence of their promoters the farmers have been convinced of the profits in growing this crop. With the limited experience of the growers, and on the various soils, irrespective of special adaptation, the average yield for this year was 72 bushels per acre, which, at 40 cents a hundred pounds, gave a gross return of $16.39 per acre. A yield of 21,000 pounds per acre has been grown on bottom lands along the small streams and creeks, which at the above price would yield $84. By proper fertilization and more intensive methods this yield should be almost equaled on the uplands.

The soils of Webster County, while producing a great variety of crops, are specially adapted to certain crops. The Clarksville stony loam is best suited to fruit, more especially apples, peaches, pears, and other tree fruits, but when newly broken yields of corn as high as bushels have been produced. The Clarksville silt loam is better suited to wheat, grass, and clover, although by methods suggested under the discussion of this type it can be made a corn soil of some merit. The Clarksville loam is more especially adapted to corn, grass, tomatoes, and small fruits.

The main line of the St. Louis and San Francisco Railroad passes diagonally across the northern part of the county, and the Kansas City, Fort Scott and Memphis branch of the same system traverses the southern part in an easterly and westerly direction. These roads afford about eight principal shipping points within comparatively easy reach of all sections. Over these lines much of the produce of the county is shipped direct to Kansas City and St. Louis. The fruit often goes to the far eastern markets.

The wagon roads of the county, besides being hilly, are very poor during the late winter and spring seasons, especially on the flat upland ridges. The roads do not follow the section lines to any great extent, but follow the ridges or the bottoms of draws instead. There is much need of road improvement in all parts of the county, but so far little has been done in this direction, although an abundant supply of the finest material is at hand.

SOIL SURVEY OF THE KEARNEY AREA, NEBRASKA.

By J. O. MARTIN and A. T. SWEET.

LOCATION AND BOUNDARIES OF THE AREA.

The area included in the present survey is that part of the Platte Valley in south central Nebraska lying between the ninety-ninth and one hundredth meridians of west longitude. It includes also about a mile of the hills or upland which bound the valley on the north and south. The area contained within the above boundaries is about 792 square miles. At the eastern end the area is about 7 miles in width, growing gradually wider as the western boundary is approached, where it has a width of about 15 miles. It is situated on the great southern bend of the Platte River, which at Kearney reaches its southern limit.

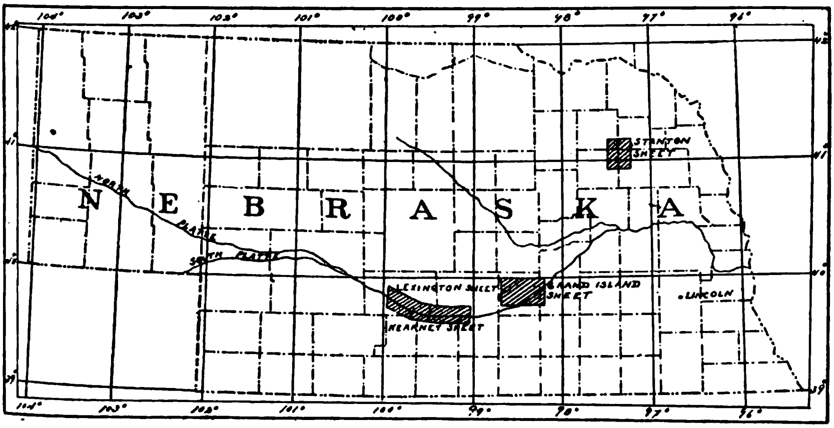


FIG. 36.—Sketch map showing location of the Kearney area, Nebraska.

Kearney lies near the eastern boundary of the area, and Cozad at the western border, with the towns of Odessa, Elmcreek, Overton, and Lexington between. Kearney is the largest town of the area, with a population of about 5,600. It is the county seat of Buffalo County. Lexington is the next town in size, with about 1,400 inhabitants, and is the county seat of Dawson County. Cozad is the third town in size, its population being 750. The other towns have less than 500 inhabitants each.

The area includes parts of Buffalo, Dawson, Phelps, Kearney, and Gosper counties. The first two lie mainly to the north of the Platte River and form the greater part of the area, while the others lie to the south of that stream.

The area is crossed from east to west by the main line of the Union Pacific Railroad, which follows in general the course of the Platte River, and it is along this railroad that all the towns of the area are situated.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

It is believed by some that the early Spanish settlers penetrated into Nebraska, but it seems more probable that the first white visitors to the region in which the present survey lies were the hardy and adventurous trappers and hunters who used the valley as a natural roadway to the western mountains. Later, the discovery of gold in California started great numbers westward and the valley of the Platte became the popular route, not only to the California gold fields, but also to those discovered later in the Black Hills.

The Mormons, passing up the Platte Valley on their way to Utah, made the first settlement in the region on Wood River, north of Kearney, in 1858. This was simply a stopping and resting station for these people on their westward migration.

Agricultural development began with the advent of the cattlemen, who grazed their herds on the natural prairie grass of what was then public land, unhampered by fences or cultivated fields.

In 1866 the Union Pacific Railroad pushed westward through the valley, and its advent marked the beginning of the real settlement of the region. The land was homesteaded by hardy pioneers, who built themselves sod houses (prairie sod being the only building material available on those nearly treeless plains), fenced their holdings, and commenced to break the virgin prairie.

The cattlemen viewed with displeasure the advent of these fence builders, and as they continued to come trouble arose between the opposing interests. The cattlemen, however, were gradually forced westward, and the region settled down to the pursuit of agriculture, for which it is so well suited.

In 1874 and 1875 great clouds of grasshoppers appeared and devoured crops and every green thing, but since that time their attacks have not been serious.

The Union Pacific Railroad originally owned large tracts of land in the valley, but this has mostly been sold to individual holders. The Government land is all taken up and the valley is now a fairly thickly settled farming region, with practically no other industries.

The climate of this portion of the Platte Valley is that of the great semiarid plain east of the Rocky Mountains. The average yearly rainfall for the last fourteen years is about 22.5 inches, as deduced from the table of precipitation given below, which was compiled from the records of the Weather Bureau station at Lexington, the most central point in the area where observations have been made. Up to 1901, however, the average was only about 20.6 inches, having been increased by the relatively heavy rainfall of the last three years.

Precipitation for fourteen years at Lexington, Nebr.

[In inches.]

Year.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1890	0.74	0.10	0.16	2.13	1.55	2.46	1.22	1.59	0.07	1.01	1.14	......	12.17
1891	1.10	.65	2.35	2.71	3.44	7.27	4.75	1.43	.81	.80	.05	1.84	27.20
1892	1.40	2.10	.90	3.08	6.55	1.11	3.61	3.56	.79	1.69	.05	.80	25.64
1893	......	1.40	1.58	2.30	3.46	2.74	2.24	1.78	1.00	.50	.15	1.32	18.47
1894	1.80	1.10	1.63	.81	.70	3.15	.94	.76	1.86	1.57	.20	.34	14.74
1895	1.20	1.40	.30	1.53	2.71	3.37	1.86	5.43	2.31	.50	2.20	.50	23.41
1896	.33	.20	1.96	4.66	3.90	1.97	2.27	1.69	3.02	1.65	.28	.20	22.12
1897	.20	.81	1.59	4.24	.30	4.61	.72	1.57	1.60	4.13	.72	1.30	21.70
1898	.30	.30	.10	2.23	2.62	4.36	1.29	2.51	2.92	.73	.80	.35	18.51
1899	.05	1.25	1.40	.47	2.66	4.12	4.06	2.39	.65	.11	1.23	.95	19.84
1900	......	1.55	.60	4.03	2.70	.94	3.56	2.51	2.71	.65	.20	.47	19.93
1901	.20	1.00	3.53	3.14	1.18	7.27	.87	2.99	5.64	1.55	.41	.65	28.43
1902	1.00	.80	.86	.72	5.72	2.98	6.28	3.39	2.64	3.66	.15	1.04	29.24
1903	.35	1.55	.83	1.15	5.80	3.18	9.24	5.42	.81	.88	.72	......	29.93

An examination of this record shows that as a rule the fall and winter months have the least rain. It shows also that there is a tendency to increased precipitation during late spring and summer, this being especially the case during the last three years, and from present indications during the present year (1904).

The average normal temperature of the area is about 49.5° F. This rather low average is due to low winter temperatures and the fact that the summers are not, as a rule, excessively hot. Frosts, both early and late, are a source of danger to growing crops, especially corn, which is sometimes ruined by September frosts. The record of killing frosts is shown in an appended table.

One of the most pronounced features of the climate of this part of Nebraska is the high winds which prevail during the winter and spring, and which are likely to occur at intervals throughout the year. These windstorms sometimes cause great damage to crops and farm buildings. In connection with prairie fires they are also a great source of danger.

Another climatic feature unfavorable to agricultural interests is found in the destructive hailstorms which occur during the growing season and often completely ruin the crops on narrow local strips.

The following table, compiled from records of the Weather Bureau, gives the normal monthly and annual temperature and precipitation at Minden and Lexington. Minden is situated in Phelps County, a short distance south of the area, but conditions at that point may be regarded as fairly representative of those in the area surveyed.

Normal monthly and annual temperature and precipitation.

Month.	Minden.		Lexington.		Month.	Minden.		Lexington.	
	Temperature.	Precipitation.	Temperature.	Precipitation.		Temperature.	Precipitation.	Temperature.	Precipitation.
	° *F.*	*Inches.*	° *F.*	*Inches.*		° *F.*	*Inches.*	° *F.*	*Inches.*
January	22.0	0.88	25.6	0.62	August	73.8	3.68	72.1	2.64
February	23.7	1.12	25.1	1.02	September	64.4	2.78	63.1	1.92
March	35.4	1.50	35.9	1.28	October	52.4	2.00	52.7	1.28
April	50.9	3.68	50.6	2.37	November	36.4	.98	36.4	.58
May	60.4	5.31	59.4	3.09	December	28.0	.71	28.6	.60
June	70.2	5.13	68.0	3.54	Year	49.4	32.45	49.2	22.00
July	75.6	4.78	72.7	3.06					

The table below gives the dates of first and last killing frosts of fall and spring during nine years past and also the average date of occurrence:

Dates of first and last killing frosts.

Year.	Lexington.		Gothenburg.	
	Last in spring.	First in fall.	Last in spring.	First in fall.
1895	May 25	Sept. 21	Apr. 22	....
1896	May 16	Sept. 18	Apr. 17	Sept. 18
1897	May 13	Oct. 8	May 13	Oct. 8
1898	May 6	Sept. 6	May 6	Sept. 6
1899	Apr. 28	Sept. 16	Apr. 21	Sept. 16
1900	May 1	Oct. 6	Apr. 17	Sept. 17
1901	....	....	....	....
1902	Apr. 25	Sept. 11	Apr. 26	Sept. 12
1903	May 8	Sept. 15	May 4	Sept. 16
Average	May 7	Sept. 20	Apr. 27	Sept. 19

PHYSIOGRAPHY AND GEOLOGY.

There are two sharply defined topographic regions in the area; one a broad, flat valley floor, the other a dissected plateau upland which borders the valley on each side. The line of demarcation between these regions is an escarpment which rises with a fairly steep grade to the level of the plateau and forms the valley wall.

The valley floor is very gently rolling and slopes to the east with a uniform fall of about 7 feet to the mile. It is undoubtedly a very old valley, cut at some former period of greater continental elevation and now partly filled with later deposits.

The bordering upland was once a nearly level, rolling plain, and even now one may look across it and receive the impression of an uninterrupted prairie with no hint of the canyonlike valleys which traverse it. This upland also has a general slope eastward.

The stream now occupying the valley is doing no cutting within this area, expending all its energy in transporting the sediments with which it is overburdened. The Platte has an average width of about three-fourths of a mile, and, owing to the fall of its valley, has an unusually straight course for an overburdened stream. During its highest periods it has an average depth of but 4 to 6 feet, while during normal flow it consists of a great number of intercommunicating shallow streams, 6 inches or less in depth, flowing between shifting sand bars and more permanent low islands. These streams are constantly changing their course as they move the sand along, and also with the shifting of the wind, which has a tendency to divert the water to the side toward which it is blowing. During the late summer and fall the Platte apparently dries up and becomes a bed of dry, wind-driven sand. There is, however, in the lower portion of this sand bed a continuous body of water known as the underflow, which never entirely fails.

The tributary streams of the Platte in this area are all small, carrying very little water except after heavy rains. They all have their source in hill valleys, out of which they flow across the valley floor in meandering trenchlike courses. Most of them are dry during the greater part of the year.

The surface deposits of this section of Nebraska are of comparatively recent geological age, and they are undoubtedly related to the Glacial period, though the relation at present is not understood.

The principal of these deposits is an extensive bed of silty and very fine sandy material which forms the plateau and probably underlies all other surface deposits. This silt loam bears a strong resemblance to the Mississippi loess in its physical properties, but differs in others. It contains the shells of fresh-water mollusks of still existing species and in places shows distinct evidences of stratification. It also contains concretions of carbonate of lime. This silt loam at lower depths grades into fine, loamy sand, and deeper still into coarse sand.

The other deposits of the region are of later date than the above and are probably underlain by it. They consist of fine sands and sand in terraces and dunes and represent late stream deposits.

SOILS.

Seven types of soil were mapped, including Meadow. The following table gives the actual and proportionate extent of each type:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Marshall silt loam	322,688	63.7	Dunesand	21,312	4.2
Meadow	46,272	9.1	Marshall fine sandy loam	15,424	3.0
Marshall loam	45,568	9.0	Total	506,688	....
Riverwash	33,984	6.7			
Marshall fine sand	21,440	4.2			

MARSHALL SILT LOAM.

The Marshall silt loam occupies the greater part of the area and is the most valuable of the soil types. The soil consists of from 10 to 14 inches of dark-brown to black silty loam, grading occasionally to fine sandy loam. It is very mellow and friable when worked under proper conditions of moisture, but cakes into large, hard clods when plowed too dry or when allowed to dry out before harrowing. The subsoil consists of a yellowish drab to gray silty clay loam, heavier than the soil, and extending from 3 to 6 feet in depth, beyond which it again grows lighter. In the lower part of the subsoil concretions of lime frequently occur. Some of this type in the valley is underlain by sand and gravel at 3 feet.

This type is derived from the basal geologic formation of this portion of the Platte Valley and probably underlies the valley in part. It forms the upland region except where it is covered by deposits of later age. It is also the predominant type of the valley itself. In the hills the Marshall silt loam once extended as a rolling plain, but is now badly cut by large, canyonlike valleys, though on the remnants of this plain there are many fine farms. The valley sides are generally too steep for cultivation and are used chiefly for pasturage.

Areas of this type in the valley proper are derived from the erosion of the valleys in the upland plateau, the materials having been carried down by the intermittent streams. These areas are almost uniformly level and frequently poorly drained. Most of the land would be greatly improved by drainage. It is almost entirely in areas of this type that alkaline conditions prevail.

The Marshall silt loam is derived from deposits of the loesslike silt which forms the valley walls, and was probably deposited in a fresh-water lake during or immediately after the Glacial period. It may be divided into two classes, viz, that derived by weathering of the original deposits, and that which has been carried into the valley by streams from the valleys eroded in the upland.

This is the most productive type of soil in the area, growing in seasons of sufficient rainfall good crops of corn, wheat, oats, rye, alfalfa, and sugar beets. Alfalfa grows especially well upon this type, and large acreages have been planted to this crop since the last census was taken, at which time the culture of alfalfa was in an experimental stage. It gives yields of from 3 to 6 tons per acre in three to four cuttings. Corn yields from 20 to 50 bushels per acre, depending largely on the season. Wheat gives an average of about 20 bushels, and oats about 30 bushels per acre. All the above crops do well when under good irrigation, and this type has a larger irrigated acreage than any of the others.

The following table gives mechanical analyses of typical samples of this soil:

Mechanical analyses of Marshall silt loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11265	7 miles SW. of Elmcreek.	Silty loam, 0 to 16 inches	0.0	0.3	0.4	2.8	19.3	69.9	6.8
11182	SE. ¼ sec. 10, T. 8 N., R. 21 W.	Silty loam, 0 to 13 inches	.0	.5	.5	2.2	38.5	46.7	11.2
11267	NW. cor. sec. 15 T. 10 N., R. 21 W.	Black silty loam, 0 to 12 inches.	.0	.0	.3	2.0	10.6	70.6	16.3
11266	Subsoil of 11265	Silty loam, 16 to 36 inches	.0	.0	.7	3.1	18.2	70.3	7.0
11183	Subsoil of 11182	Very fine sand and silt, 13 to 36 inches.	.0	.2	.1	.6	37.2	50.6	11.3
11268	Subsoil of 11267	Gray, heavy, silty loam, 12 to 36 inches.	.0	.0	.0	1.2	4.6	66.5	26.9

MARSHALL LOAM.

The soil of the Marshall loam consists of 10 to 12 inches of brown to black very fine sandy to silty loam, easily worked, but not as strong and durable as the type just described. In this area there are no stones present in this type, either in soil or subsoil.

The subsoil consists of very fine sand and silt to a depth of 3 feet or more, beyond which it changes suddenly to the black soil of the Marshall silt loam, over which it has been deposited. Occasionally this underlying soil comes nearer to the surface than 3 feet, but only in small areas of less than 10 acres.

This type is found both on the valley floor and on the upland border. On the valley floor it occurs in narrow strips along sloughs and stream courses, and bordering sandy areas.

It generally is slightly more rolling than the Marshall silt loam, but most of it is quite level. It is usually marked at the boundary by slight rises above the general level. Some isolated mounds of it also occur. This is a well-drained type, but it does not resist drought as well as the Marshall silt loam.

The Marshall loam is derived from two sources, one an outcrop of very fine sandy and silty material underlying the Marshall silt loam, the other consisting of stream deposits. The first of these is of unknown depth; the other is from 2 to 3 feet deep, and is underlain by the silt loam. Some of this type contains alkali when not well drained, but on most of it the drainage is good enough to prevent alkaline conditions.

On this type are grown the same crops that are found on the Marshall silt loam, with the same average yields in ordinary seasons. In dry seasons, however, it does not resist drought so well, and gives lower yields. During the last three wet seasons alfalfa has done better on this type, as it is less likely to be "drowned out."

The following table gives mechanical analyses of typical samples of this soil:

Mechanical analyses of Marshall loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11259	5 miles SW. of Elmcreek.	Very fine sandy loam, 0 to 12 inches.	0.0	0.3	0.7	9.2	35.0	48.7	5.8
11261	¼ mile N. of Lexington.	Silty loam, 0 to 10 inches.....	.0	.2	.3	4.2	30.0	56.6	8.3
11262	Subsoil of 11261 ..	Silty and fine sandy loam. 10 to 36 inches.	.0	.2	.2	7.9	35.4	49.3	6.4
11260	Subsoil of 11259 ..	Fine sandy loam, 12 to 36 inches.	.0	.2	1.1	13.2	33.7	42.8	8.5

MARSHALL FINE SANDY LOAM.

The Marshall fine sandy loam consists of 10 to 14 inches of coarse to medium sandy loam, with a few scattered pebbles of small size on the surface. The subsoil is a sandy loam, with some clay and silt, and is heavier than the mellow soil. The subsoil contains some gravel and is generally underlain by gravel.

This type is found entirely within the valley, where it occurs as low terraces, and also as ridges and mounds. It is a well-drained type and is therefore generally free from alkali.

This soil was formed by stream action at some period when the rainfall was much greater than it is at present. It represents deposition at a level far beyond the reach of the present stream.

The type produces good yields of corn, wheat, oats, rye, alfalfa, and sugar beets.

The following table gives mechanical analyses of typical samples of the Marshall fine sandy loam:

Mechanical analyses of Marshall fine sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11253	¼ mile E. of Kearney.	Black sandy loam, 0 to 14 inches.	1.7	8.3	13.6	29.8	16.1	22.5	7.6
11255	2¼ miles SE. of Lexington.	Black sandy loam, 0 to 12 inches.	1.9	9.8	12.8	26.5	15.0	26.2	8.1
11254	Subsoil of 11253..	Gray sandy loam, 14 to 36 inches.	1.4	10.0	15.3	32.8	13.4	14.4	12.2
11256	Subsoil of 11255..	Gray sandy loam, 12 to 36 inches.	2.0	8.9	15.5	31.0	12.6	15.3	14.4

MARSHALL FINE SAND.

The soil of the Marshall fine sand is a yellow to black fine sand or loamy sand, underlain by fine sand of the same general texture, but as a rule lighter in color.

This soil occurs as gently rolling terraces at the edge of the valley and as elevated regions on the valley floor. It is so well drained that in dry seasons crops do not resist drought well, and consequently do not give as large yields as on the other types.

The Marshall fine sand results in most cases from a stream deposition laid down on the basal loess. It occurs, however, as an outcrop underlying the loess and fine sand along the western end of the south valley wall.

This type is planted to the same crops as the other types, but as a rule the yields are not so good. Alfalfa especially does not seem to do so well on this type, though some very good fields were observed on it during the progress of the present survey. Probably two-thirds of it is in pasture, and wild grasses seem to do well.

The following table gives mechanical analyses of typical samples of this soil:

Mechanical analyses of Marshall fine sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11247	NE. cor. sec. 2, T. 9 N., R. 21 W.	Brown loamy sand, 0 to 14 inches.	1.0	9.2	12.7	37.7	20.5	12.1	6.7
11249	Cen. N. side sec. 12, T. 9 N., R. 23 W.	Black loamy fine sand, 0 to 12 inches.	.0	1.6	4.8	41.0	33.8	11,5	7.0
11250	Subsoil of 11249	Brown fine sand, 12 to 36 inches.	Tr.	1.4	5.9	50.5	29.1	7.4	5.6
11248	Subsoil of 11247	Yellow fine sand, 14 to 36 inches.	.6	5.1	11.0	35.9	27.7	10.9	8.9

DUNESAND.

The Dunesand type of this area shows no appreciable difference between soil and subsoil. Until a very recent period it consisted of shifting sand blown about by the wind, but it is now held down in most places by wild grasses and various sand-growing plants. It is loose incoherent sand of little agricultural value.

As above noted, the type is an æolian deposit, but its source is not easy to determine, especially when it occurs as isolated patches in the center of the valley. It has a very low crop value, though it is sometimes planted to corn, wheat, rye, and oats. The yields are small and are likely to fail without plenty of rain. Its greatest present value is as pasture, and most of it is now utilized for that purpose.

The following table gives mechanical analyses of typical samples of Dunesand:

Mechanical analyses of Dunesand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11271	4 miles S. of Elm creek.	Loose fine sand, 0 to 10 inches.	Tr.	0.8	8.2	74.2	13.6	0.2	2.8
11273	Cen. sec. 7, T. 9 N., R. 22 W.	Loose fine sand, 0 to 12 inches.	.0	.6	5.6	56.5	30.2	1.0	6.2
11272	Subsoil of 11271	Loose fine sand, 10 to 36 inches.	.0	1.8	9.9	71.5	14.4	.1	2.6
11274	Subsoil of 11273	Loose fine sand, 12 to 36 inches.	.0	.7	6.0	62.5	25.4	.2	4.8

Meadow in this area represents the lowest level lands bordering the Platte River, as well as the islands in that stream. The soil is variable, being sandy, gravelly muck, and even clay, with various subsoils. A great deal of it is sandy loam, with many different subsoils.

The type is nearly level, and is broken only by low ridges and sloughs lying parallel to the river. Much of it is true swamp.

The water table everywhere lies from a few inches to 3 feet from the surface, and alkali often shows white on the surface, though its amount seldom reaches 0.20 per cent.

Much of the Meadow is cultivated, and in dry seasons grows very good crops, but in wet seasons most of it becomes so wet that crops can not be harvested. At Kearney large, mucky tracts are planted to celery, which does very well. The usual crops of the area are all grown in the Meadow soil, though 75 per cent of it is in pasture or growing wild grass, which is cut for hay. It is probably better adapted to pasturage than to the growing of cultivated crops.

RIVERWASH.

The Riverwash of the Platte River bed consists mainly of coarse, quite sharp sand, with streaks of gravelly sand, the gravel stones rarely reaching an inch in size. These gravel streaks are found more commonly in the numerous side channels, though they often occur in mid-stream. The sand is sharp for a river sand, and makes a good building sand, which is the only value possessed by this type. Part of the year it is covered by water, and shifts and moves with the currents, while during the rest of the year it is dry, blowing about with the winds.

WATER SUPPLY FOR IRRIGATION.

During the last four years, owing to the abundant rainfall, there has been little need of irrigating water, but prior to that time there were constructed extensive systems of irrigation canals, which cover a large part of the valley. The Platte River is the sole source of water supply for these canals, and thus far has proved far from reliable. During the spring months it generally contains sufficient water to fill the canals, but at this time there is usually enough rainfall. Later on, when the crops are maturing and water is most needed, the Platte sinks to the underflow stage, which has heretofore proved insufficient to supply the water rights now sold, to say nothing of the lands under ditches which are not provided with such water rights. Plans for a more complete utilization of this underflow water are contemplated, but the abundant rains of the last four years have brought irrigation projects to a standstill.

Storage reservoirs are not practicable within the area, on account of the lack of suitable sites. The most feasible sites for reservoirs are near the western boundary of the State or in Wyoming. Up to the present all of the canals have been dependent upon the uncertain flow of the Platte River. During the present summer the Platte reached its highest recorded stage, but this supply was not used, as the abundant rains precluded the need of irrigation. In fact, during the last four years there has developed a greater need for drainage than for irrigation ditches.

UNDERGROUND AND SEEPAGE WATERS.

There is a never-failing and abundant supply of underground water in the area for stock-watering and household purposes, but it is doubtful if any very extensive irrigation could be accomplished from this source, even if the water were suitable for such purposes. Most of it appears to contain a relatively high percentage of soluble salts. The water table lies at distances from the surface ranging from a few feet to about 40 feet. There are generally two veins of water, the upper of which contains the higher percentage of soluble salts. The lower is generally the one tapped for domestic use.

The large percentage of silt in the soils through which most of the irrigation ditches are dug prevents any great loss from seepage, and the rains have kept the soils so saturated of late that there is little chance for observation on the amount of seepage. It is said, however, that a few lands have been damaged in this manner.

ALKALI IN SOILS.

Beginning at Odessa and stretching westward, there is an area in which much of the soil contains enough alkali to be injurious to crops. For the most part the alkali spots lie north of the Platte River, but there are a few south of that stream. These alkali areas grow larger and more numerous toward Lexington, beyond which they gradually diminish in size and number, so that the worst affected areas are to be found between Lexington and Overton. They follow approximately the line of the Union Pacific Railroad, the main body being on the north side of its tracks. Patches of alkali land extend as far west as Gothenburg, a distance of 14 miles beyond the western boundary of the present area. They diminish, however, toward that point. The areas south of the Platte River occur south of Lexington and Cozad.

The origin of this alkali is not obvious, but it appears to be an accumulation through many years of wash from the upland valleys, traces of alkali in small amounts frequently showing on the sides of these valleys. Washed into the valley and remaining in its most poorly drained portions, these small amounts become concentrated by evaporation during the dry seasons. The ground water also becomes in like manner impregnated to a greater or less degree with alkali, and, where it is near the surface, as is frequently the case, becomes a continuous source of supply. The ground water is not of a uniform concentration, but varies with the conditions of its flow. The fact that in most instances the alkali areas are poorly drained seems to indicate that the above is the origin of these troublesome deposits.

The chemical composition of the alkali in these areas is quite variable. It consists mainly of salts of sodium, potassium, and calcium, with some magnesium in different combinations. The appended table shows an analysis of a fair average sample of surface drainage water taken after a heavy shower, and consequently containing a complex sample of the surface alkali; also the analysis of a sample of ground water taken at a depth of 3 feet. Both samples were taken at Lexington, in a badly alkaline area.

Analysis of drainage and ground water from alkali tract.

Constituent.	Drainage ditch near Lexington.	Ground water near Lexington.
Ions:	*Per cent.*	*Per cent.*
Calcium (Ca)	2.68	1.34
Magnesium (Mg)	.80	1.06
Sodium (Na)	19.26	13.35
Potassium (K)	9.83	19.03
Sulphuric acid (SO_4)	21.50	7.44
Chlorine (Cl)	1.56	1.69
Bicarbonic acid (HCO_3)	37.18	50.44
Carbonic acid (CO_3)	7.19	5.65
Conventional combinations:		
Calcium sulphate ($CaSO_4$)	11.80	4.59
Magnesium sulphate ($MgSO_4$)	3.98	5.27
Conventional combinations—Continued.	*Per cent.*	*Per cent.*
Potassium chloride (KCl)	3.39	3.67
Potassium bicarbonate ($KHCO_3$)	20.46	43.67
Sodium sulphate (Na_2SO_4)	13.63	....
Sodium bicarbonate ($NaHCO_3$)	34.05	32.80
Sodium carbonate (Na_2CO_3)	12.69	10.00
Total solids	223.80	207.00

From the above it will be seen that the ions of soda and potash form the main alkaline salts. The surface water showed by the phenolphthalein test a strong reaction for carbonates, while the soil water showed but a trace, which has proved to be the case in all of the alkali areas examined. Wherever there was carbonate or black alkali it was in the crust or surface inch or two, and not enough black alkali was encountered to warrant making a separate map. The carbonate, where observed, was invariably in the most poorly drained localities, and seemed to be due to the effect of decaying vegetation upon the bicarbonates, which form the bulk of the alkali.

The distribution of the alkali in the soil is very irregular, scarcely any two borings giving the same result. Where the water table lies close to the surface the alkali is in the few feet of unsaturated soil.

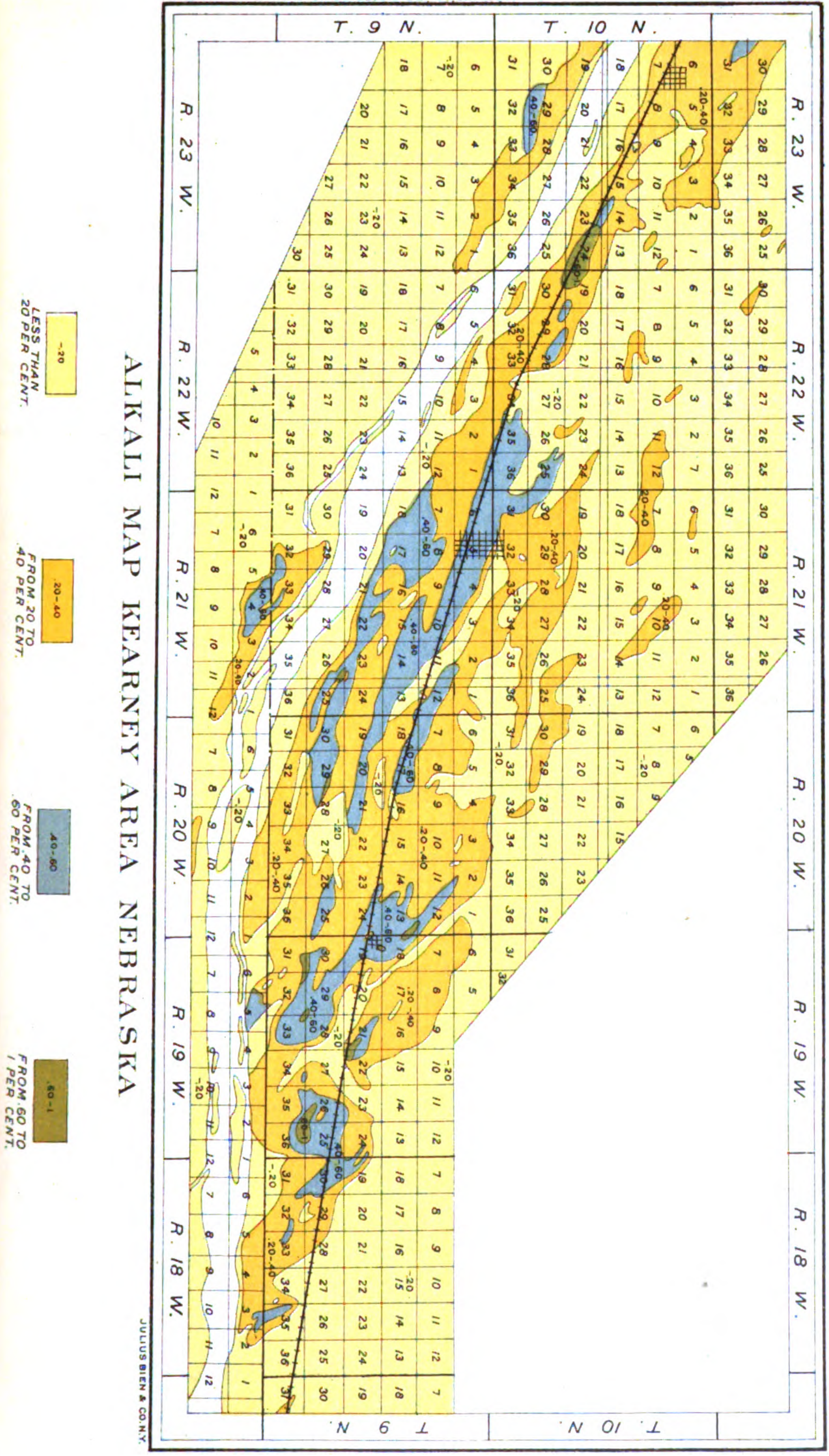
A few instances were noted where the alkali was present in considerable quantity throughout the 6-foot section, but in the majority of cases the bulk of it was in the second and third feet. Many times good fields of alfalfa were noted on 0.40 to 0.60 per cent alkali areas, with no trace showing on the surface; in other instances the surface was coated with alkali crust and readings of but 0.20 to 0.40 per cent obtained. Where the alkali was found in the third foot it could be easily distinguished as white spots throughout the subsoil, but cases were observed where these spots were not visible, though alkali existed. There seems to be no general rule for the vertical or horizontal distribution, and its irregularity is probably due to the unequal passage of water through these poorly drained soils. It seems probable that the unusually wet season of the present year has had something to do with the unequal distribution in carrying the alkali from the soil to the subsoil, or in washing it completely out of the surface foot, and it is probable that during a dry season the percentages for these areas would be much higher.

From the results of experiments in other areas it seems feasible to reclaim a great deal of this alkali soil, but, judging from the general conditions, it would probably require cooperative effort. All of these soils would be greatly benefited by drainage, but the falls are so slight that the drainage of individual tracts would be very difficult, and the result could best be accomplished by the construction of large public or corporate ditches, into which individuals could discharge their drains.

A great part of the worst alkali land is underlain at from 3 to 6 feet by a sandy and gravelly layer, which at all times contains water carrying relatively large quantities of salts. Ditches would have to be of sufficient depth to drain thoroughly this sand layer, after which the addition of tile drains would make the problem of reclamation a simple one. The expense of this work would undoubtedly be more than compensated by the increased value of the land. The position of these alkali soils, located as they are in close proximity to a trunk railroad, makes them of considerable value, and they are well worth the expense of reclamation.

AGRICULTURAL METHODS.

The methods of farming in the area are extensive rather than intensive. Large acreages of the crops grown are planted, and both planting and harvesting are done with the latest and most improved machinery. Cornfields with rows half a mile in length and quarter-



ALKALI MAP KEARNEY AREA NEBRASKA

T. 9 N.
T. 10 N.
R. 23 W.
R. 22 W.
R. 21 W.
R. 20 W.
R. 19 W.
R. 18 W.
-20 LESS THAN 20 PER CENT.
.20-.40 FROM .20 TO .40 PER CENT.
.40-.60 FROM .40 TO .60 PER CENT.
.60-1 FROM .60 TO 1 PER CENT.
JULIUS BIEN & CO. N.Y.

sections of wheat and oats are not uncommon, and occasionally whole sections of a single crop may be observed. This is made possible by the exclusion of hand work and the use of machine cultivators that enable one man to keep in cultivation a hundred acres or more of corn. Four to six horses are generally employed, and cultivation is usually deep and thorough. There is a tendency, however, in plowing large areas to allow such fields to dry out on the surface before harrowing, and the Marshall silt loam is inclined to clod under such conditions. This tendency could be obviated by following up the plows closely with the harrows and breaking up the soil while it is still mellow.

AGRICULTURAL CONDITIONS.

The general prosperity of the farming classes is much greater than that of the same classes in eastern areas. During the last four years of abundant rains good crops have been the rule, and this, with the small expense of operation and the good prices obtained, has placed most of the farmers on a sound financial basis and enabled them to free themselves from debt. Few of the farms are now mortgaged, and when so mortgaged are regarded as the best of security. Many farmers have money to loan. Over 50 per cent of the farms are rented, the owners being in business in town or retired from active work, and their farms give good returns to both owner and operator.

The average size of farms in the area is about 250 acres, the largest containing several sections and the smallest about 40 acres. Quarter-section farms are the most frequent, but there are many containing half or even a whole section.

Farm labor is scarce and inefficient, but commands high prices. This is especially true during harvest time, when hands receive as much as $1.50 or $2 a day.

The principal farm products of the area are corn, wheat, oats, rye, alfalfa, sugar beets, and cattle and dairy products, the latter just now coming into prominence. A great deal of the grain is shipped out of the area, every railroad having one or more elevators. A large part is ground in the area by the various roller mills, and the remainder is fed for fattening cattle and hogs—an important industry of the area. Corn is at present the principal crop, with wheat second and oats third. Alfalfa is fast increasing its acreage and seems especially adapted to the area. It is the best forage crop available and gives good yields, being especially valuable in fattening cattle and hogs. Some millet is grown as forage, and also some Hungarian grass, but these are not extensively produced. There is a market for sugar beets at both Grand Island and North Platte, but at present the acreage of this crop for the whole area is small. Vegetables are grown chiefly for home consumption, but potatoes are shipped in small quantities. Wild prairie or meadow grass is also an important product.

The broad, level, easily cultivated prairies are well adapted to the crops above mentioned, the Marshall silt loam being especially productive and adapted to corn, grain, and alfalfa.

The sole avenue of transportation for most of the area is the Union Pacific Railroad, though at Kearney there is a branch of the Burlington and Missouri River Railroad. Freight rates are high, and the movement of crops is impeded at times by lack of cars or congestion of traffic.

Omaha is the grain and cattle market nearest the area, and to this point most of the products are shipped.

SOIL SURVEY OF ALLEN COUNTY, KANSAS.

By **J. A. DRAKE** and **W. E. THARP.**

LOCATION AND BOUNDARIES OF THE AREA.

Allen County lies in the third tier of counties from the southern and second from the eastern boundary of the State, and is just 24 miles north of the Parsons area, which was surveyed during the season of 1903. The present survey covers the entire county, or an area of 322,560 acres, or 504 square miles. Much the same soils, soil conditions, and agricultural practices were found in Allen County as in the Parsons area, and the status of the agricultural class is equally satisfactory in the two areas.

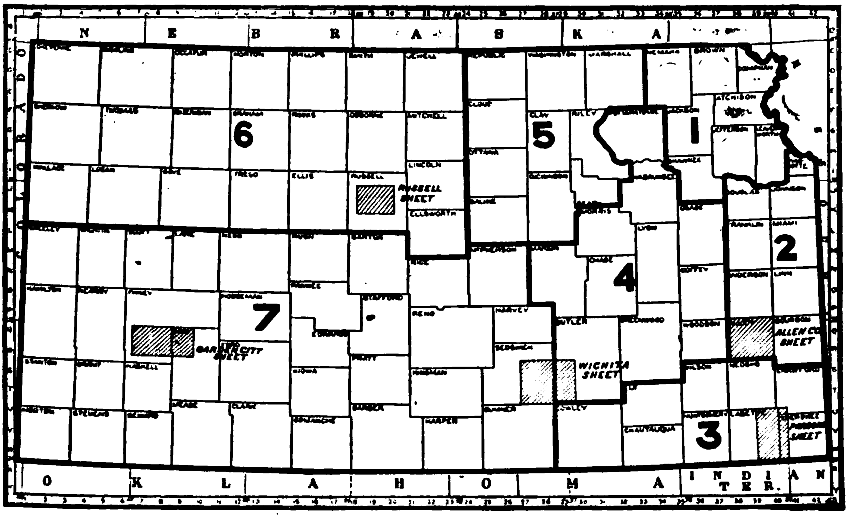


FIG. 37.—Sketch map showing location of the Allen County area, Kansas.

The Neosho River flows through the western part of the county for nearly its entire length from north to south. The county seat is Iola, situated on this river, and at the intersection of the Atchison, Topeka and Santa Fe, the Missouri Pacific, and the Missouri, Kansas and Texas railroads. Humboldt, Moran, and Laharpe are the other important towns.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The first homestead claims were selected in the Neosho Valley in 1855, and during the same year a county organization was effected and the boundaries of Allen County fixed almost as they are at present. A new town, known as "Cafochique," which was soon afterwards abandoned, was made the county seat. From this time until the civil war immigration was quite rapid, the older States, especially Indiana and Illinois, contributing large numbers of settlers.

In 1860 a very serious drought caused an almost total failure of crops, and it is reported that out of the 3,000 persons then residing in the county a great majority moved away, never to return. In 1866, and again in 1874, swarms of grasshoppers appeared, consuming almost every particle of green vegetation, especially in the valleys, and these years also were periods of great discouragement.

In the spring of 1870 the Missouri, Kansas and Texas Railroad was built as far as Humboldt, and in the fall of that year the Leavenworth, Lawrence and Galveston Railroad, now a division of the Atchison, Topeka and Santa Fe, was completed across the county. Both roads received grants of public land, most of which was in the eastern part of the county. The railway companies soon disposed of this land, the greater part passing into the hands of nonresidents. In the early seventies the assertion was quite generally made that these companies had not complied with the terms of the original grants, and that consequently their titles were defective. Squatters claiming rights under the homestead laws proceeded to occupy almost every quarter-section not actually held by resident owners. Much trouble arose, for many transfers had been made prior to and during the time the ownership was unsettled. These land cases and indictments for numerous crimes resulting therefrom were in the Allen County courts for more than twenty years. Pending the settlement of these disputes, about 57,000 acres of land remained unimproved, and agricultural development in general was greatly retarded.

Allen County has at no time been a part of the great range district, most of its lands having been occupied by farmers before the cattle industry of the West assumed great proportions. Corn has always been the principal crop, but wheat and oats have been more or less important at different times. Until recently the growing of wheat had been almost discontinued, owing to the belief on the part of the farmers that it fostered chinch bugs, but the acreage in this crop is now being rapidly increased. Clover, timothy, and a few other tame grasses have been cultivated for about twenty years, but to no great extent until recent years. Broom corn at one time was quite important, but is at present confined principally to the southeastern part of the county, in the Swedish settlements near Elsmore and Savonburg. In this same section, about fifteen years ago, the castor bean was extensively cultivated, but this industry has now been entirely abandoned.

CLIMATE.

The climatic conditions of Allen County are characterized by somewhat open winters and a long growing season, the early part of which is often wet and the latter part dry, each often being so extreme as to reduce greatly the crop production of the county.

The following table, compiled from the records of the Weather Bureau station at Moran, shows the normal monthly and annual temperature and precipitation:

Normal monthly and annual temperature and precipitation.

Month.	Moran.		Month.	Moran.	
	Temperature.	Precipitation.		Temperature.	Precipitation.
	°F.	*Inches.*		*°F.*	*Inches.*
January	32.8	1.33	August	78.7	4.51
February	30.2	1.75	September	69.6	4.54
March	43.0	2.59	October	60.7	2.03
April	55.8	3.11	November	45.4	1.41
May	66.6	4.67	December	33.0	2.24
June	74.0	4.92	Year	55.7	36.82
July	78.6	3.72			

PHYSIOGRAPHY AND GEOLOGY.

The geology of Allen County is also similar to that of the Parsons area. In each the formations consist of alternating beds of shale and limestone belonging to the Carboniferous system. The stratigraphic formations of this area, however, are later deposits forming the basal members of the Upper Coal Measures. These strata are conformable one with another and have a slight dip to the north and west, thus successively exposing five formations, as recognized by the State geologists. Each of these outcrops reveals itself in the characteristics of the soil formed thereon and by peculiarities of the surface.

In the southeast corner of the county the very rolling land along Marmaton Creek is the result of the erosion of the bed of this stream through limestones of the Erie formation. The large, light-colored chert fragments so abundant in this locality are associated with this particular rock. The upper stratum of this limestone and the included chert is exposed along the banks of Big Creek.

The Thayer shales which overlie the Erie formation have furnished the surface materials for a narrow area extending in a northeast and southwest direction from the Little Osage River to the vicinity of Leanna. The sandstone strata occurring in this formation have given rise to the sandy soils found on the flanks of the ridges or forming the tops of the more prominent elevations. The greater part of these shales, however, are less arenaceous, and weather into soils of finer texture.

The Iola limestone is the next higher member in the geologic column, and is much in evidence at Humboldt and on the adjacent uplands east of the Neosho River. It is a hard, crystalline rock, having few seams or fractures, and, considering its thickness and nearly horizontal position, has affected but a limited extent of surface.

The Lane shales lie above the Iola horizon, and have a wide exposure through the central part of the area, contributing liberally to the formation of the Oswego silt loam of this section.

The uppermost member of the geologic column, the Garnett limestones, outcrops near Carlyle. The different strata of this formation have formed the limestone lands lying between Deer Creek and the northern boundary of the county. They also appear west of the Neosho River.

This brief reference to the geology of the area is, in a measure, descriptive of its physiography. There are no topographic features of exceptional prominence, nor any considerable extent of surface deficient in drainage. The Neosho River flows in an east and southeast direction through the western part of the county. Bear, Elm, and Coal creeks are tributaries from the east, the latter two having their sources within the county. The valley of the Neosho varies from 1 to 3 miles in width, but in most of its broader expansions there are well-defined terraces or "second bottoms" between the flood plain proper and the lower slopes of the bordering uplands. Within the limestone areas the small streams have narrow valleys, or flow through mere channels bordered by rough, stony land. But the wide exposures of the soft shales have weathered to a surface characterized by broad depressions separating gentle undulations that succeed each other until interrupted by the more rugged limestone topography. Sometimes the relief becomes more pronounced by the rise of a gravelly knoll or the presence of a sandy ridge. In the western part of the county some thin limestone layers, remnants of the Garnett system, have protected the shales beneath, thus forming flat-topped elevations varying from a few acres to a square mile or more in extent.

In general, the major part of this area may be described as a gently rolling upland, rising from 40 to 100 feet above the valleys of the larger streams. The extreme elevation, about 1,100 feet above sea level, is attained near Moran. Aside from a few stony bluffs, the are favorable to agriculture.

SOILS.

Eleven types of soil, including the Rock outcrop and Rough stony land, were recognized and mapped in the survey of Allen County. The following table shows the actual and relative extent of each:

Area of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Oswego silt loam	177,600	55.8	Sharkey clay	2,739	0.8
Sedgwick clay loam	75,239	22.4	Yazoo clay	2,560	.8
Yazoo loam	20,531	6.4	Yazoo sandy loam	909	.3
Oswego fine sandy loam	15,565	4.9	Rock outcrop	870	.3
Rough stony land	12,211	3.8	Total	322,560	
Neosho silt loam	9,171	2.9			
Sedgwick gravelly loam	5,165	1.6			

OSWEGO SILT LOAM.[a]

The Oswego silt loam, commonly known as "white, ashy land," covers the greater part of the upland portion of the area. The soil varies in depth from 7 to 18 inches, with an average of about 12 inches. It is best described as a gray to dark-gray, more or less ashy silt loam, containing small and varying amounts of very fine sand, which is scarcely discernible with the ordinary means of observation. With thorough preparation it is reduced to a loose, friable, dusty condition, but becomes compact and massive when left thus for some time undisturbed. When in this state there is a slight tendency to crack, and on the whole a disposition to dry out rapidly. When wet the color of the soil becomes darker and approaches almost a black in the depressions, where also there is occasionally a tendency to a slightly more clayey texture. Except in these small areas there is a general deficiency of organic matter.

Underlying the soil from 12 to 36 inches is found a dark-drab to yellow silty clay subsoil, compact, stiff, and impervious, and popularly known as "hardpan." In the depressions the color of this material becomes much darker, and there is a slightly higher clay content. The subsoil of the Oswego silt loam, from its nature and extent, may result in a marked decrease in the production of crops in the area during a wet season. Special reference is made to this problem in a subsequent part of this report. Where closely associated with the Sedgwick clay loam or the Oswego fine sandy loam this hardpan condition is often lessened or wholly removed by the formation of a looser and more friable structure, which promotes a better subdrainage. The material also becomes loose and granular upon exposure to the atmosphere, and where it can be mixed with the surface soil the mechanical condition of the latter will be greatly improved and the yield of crops increased. At present the plowing on this type of soil is generally too shallow for the best results.

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[a] The Oswego silt loam is the same soil as the Oswego loam of the Parsons area, Kansas. The Oswego silt loam of the latter area will be correlated with some other type.

The Oswego silt loam is found in almost all parts of the area and often extends in unbroken bodies for several miles. It occupies slopes, depressions, and elevations. Leaving the areas of the Sedgwick clay loam in the north-central and northwestern parts of the county, it occupies first the more abrupt slopes and narrow depressions, then extends into a broad and expansive depression to the northeast of Iola, and assumes the form of a broad and slightly irregular upland to the north of Laharpe and Moran. In the vicinity of Gas it begins to occupy the elevations and slopes, the Sedgwick clay loam occupying the depressions; thence south and southeastward the types alternate in this respect.

Except where the type occurs on very gentle slopes or in slight depressions the topography is such as to give apparently good surface drainage, but in times of extreme and continued rainfall crops suffer greatly from the lack of subdrainage, the impervious subsoil holding an excess of moisture too near the surface.

The weathering of the different beds of shale found in the county has given rise to this soil. Owing to the thickness of these beds in some places the type occupies elevations varying from 40 to 50 feet within comparatively short distances, while in others a slight difference will effect a change in soil type, so that elevation and general topography are no guide to its occurrence.

Owing to its silty texture and tendency to pack, the Oswego silt loam is naturally adapted to the growing of wheat. Broom corn yields well, and likewise corn, where the land has not been carelessly farmed for long periods. By applying manures and thus increasing the organic matter, and by improving the mechanical condition of the subsoil as suggested, the Oswego silt loam will prove equal if not superior to any of the other upland types for general agricultural purposes. With small applications of fertilizer, wheat yields about 18 bushels; corn, about 20 bushels on an average, without fertilizers; and oats, 25 bushels per acre. Broom corn averages about one-fourth of a ton per acre; native hay, 1 ton; and clover and timothy, from 1 to 1½ tons. Much of the type is at present in a low state of productiveness, but by skillful management and proper cultivation its crop yields can be greatly increased.

The following table shows the results of mechanical analyses of both soil and subsoil of the Oswego silt loam:

Mechanical analyses of Oswego silt loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11857	½ mile E. of Elsmore.	Silty loam, 0 to 14 inches.	0.2	1.1	0.9	2.1	7.8	76.9	10.7
11855	3½ miles NE. of Iola.	Silty loam, 0 to 10 inches.	.1	.8	.7	1.7	8.5	75.7	12.6
11853	4½ miles S. of Iola	Silty loam, 0 to 10 inches.	.1	.7	.8	1.2	10.9	71.1	14.6
11854	Subsoil of 11853	Silty clay, 10 to 36 inches.	.0	.6	.5	1.9	8.0	67.8	20.8
11856	Subsoil of 11855	Silty clay, 10 to 36 inches.	.1	.5	.4	2.0	5.5	67.6	23.8
11858	Subsoil of 11857	Silty clay, 14 to 36 inches.	.0	.4	.3	2.5	6.2	62.0	28.4

SEDGWICK CLAY LOAM.

The Sedgwick clay loam is the second in importance of the upland types. From its prevailing reddish tinge it is known locally as "red land." The upper 10 inches consists of reddish-brown to black silty loam to clay loam, rather granular, but loose and friable, and containing a relatively high percentage of silt. Underlying this is a red to reddish-brown, and occasionally black, silty clay to clay subsoil, generally somewhat open and granular, but becoming compact and stiff near the bottom of the soil profile. This in turn rests on limestone at depths ranging from 25 to 60 inches.

Being naturally a strong soil, and having a subsoil somewhat more open, this type is preferable to the Oswego silt loam during wet years, and is thought by many to stand drought equally well. Owing to its nearness to rock, however, and its peculiar texture, it has a decided tendency to dry out and to become deficient in moisture during continued periods of dry weather. This feature makes it necessary to practice frequent cultivation, which should be shallow, the surface being kept as level as possible. When this is begun early and the soil is kept in good tilth till late in the growing season, corn suffers but little from drought and often yields as much as 50 bushels per acre.

The largest area occurs in the northern part, but the type is encountered in almost all parts of the county. Being the product of the weathering of different layers of limestone, it occupies alternately the tops and slopes of elevations, ridges, and depressions, depending on the position the formation from which it is derived occupies with reference to the beds of shale between. Where found on the elevations it has good natural drainage, but drainage is very deficient in the depressions, where the type is often used for pasture only.

The Sedgwick clay loam is naturally best adapted to corn, but all the general farm crops of the area do well. Wheat possibly does not yield as well as on the Oswego silt loam, being somewhat more subject to the effects of freezing and thawing. It is the general opinion that alfalfa dies out in about three years, but an instance was observed where by two years of deep plowing and manuring a stand was secured that had yielded about a ton per cutting and had been cut four or five times each year for twelve years. It is reasonable to suppose that by thoroughly preparing and manuring the soil better success could be had in growing this valuable crop. There must, however, be good surface drainage and sufficient depth of soil. Clover and timothy together do well, producing from 1 to 2 tons per acre. Corn will average about 22 bushels, oats 25, wheat about 16, and flax from 6 to 10 bushels per acre.

The following table shows the results of mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Sedgwick clay loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11861	5 miles N. of Iola	Silty loam, 0 to 10 inches.	0.0	0.4	0.4	2.9	8.9	69.4	17.8
11863	8½ miles NW. of Elsmore.	Silty loam, 0 to 12 inches.	.1	.5	.5	1.7	8.9	63.4	24.8
11865	1 mile N. of Bayard	Clay loam, 0 to 12 inches.	.1	.3	.3	1.8	5.4	64.5	27.6
11862	Subsoil of 11861	Silty clay, 10 to 36 inches.	2.6	2.9	.9	1.6	3.8	64.5	23.3
11866	Subsoil of 11865	Silty clay, 12 to 36 inches.	.1	.5	1.1	11.9	5.3	50.6	30.6
11864	Subsoil of 11863	Silty clay, 12 to 36 inches.	.6	.6	.4	2.2	6.2	53.3	36.7

NEOSHO SILT LOAM.

The soil of the Neosho silt loam is a light-colored, somewhat ashy silt loam to a depth of 8 inches, in which small and varying amounts of fine and very fine sand are incorporated. This sand content would be expected to benefit the soil materially by improving its mechanical condition, yet owing to its silty texture and the depletion of organic matter by long cultivation, it has a decided tendency to run together in a dense mass, which renders fall and summer plowing to any reasonable depth very difficult, unless done when the soil is wet. When dry for some time the soil has a tendency to crack, the cracks often having a depth of from 6 inches to 1 foot, which permits a rapid escape of the moisture in the soil and subsoil. Thorough cultivation of the soil reduces it to the consistency of dust, which in turn forms a compact mass again if not cultivated continually. On the whole, there is a marked deficiency of organic matter, which should be supplied by turning under coarse stable manure and green manures. These should be plowed in deeply, turning the soil to a depth of at least 8 or 10 inches.

From 8 to 25 inches the subsoil is a dark, very compact, and impervious silty clay, with little power to retain moisture, and becoming dry and difficult to bore soon after rains. Below this, to a depth of 36 inches, there is almost always found a mottled yellow and grayish-white sandy material, which is loose and powdery when dry, and cuts off the water supply from below, although sometimes the subsoil is composed entirely of the compact clay always occurring immediately below the surface soil.

The occurrence of the Neosho silt loam is confined to terraces, lying from 5 to 15 feet above the level of the river bottom proper, and is locally known as "second bottom." It doubtless marks a flood plain of the river before it had cut down to its present level, and in the case of the area along Deer Creek it probably marks a former level of that stream. The elevation of the type is sufficient to insure it against danger from floods, and to afford a fair means of surface drainage. The surface presents a flat or gently rolling topography, however, which does not hasten the surplus water to the small streams or ditches. This, together with the impervious character of the subsoil, is often responsible for damage to crops. Deep plowing or subsoiling would doubtless do much to improve the drainage conditions in such cases.

Although generally greatly influenced by the adjoining uplands, the Neosho silt loam is largely of alluvial origin. It has lost most of the characteristics of a typical alluvial soil by subsequent weathering, and has no resemblance to the soils of the first bottom.

The type is probably best adapted to wheat, but corn and oats do well when the season is not extremely wet or dry. Twenty-five bushels of wheat per acre can often be grown, and as much as 50 bushels of corn and 30 bushels of oats; but owing to the effect either of excessive moisture or drought the general average is much lower.

The following table shows the results of mechanical analyses of the soil and subsoil of the Neosho silt loam:

Mechanical analyses of Neosho silt loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11846	5 miles SW. of Iola	Silty loam, 0 to 8 inches	0.2	1.0	2.1	5.5	18.0	59.3	13.6
11844	1¼ miles NW. of Humboldt.	Silty loam, 0 to 6 inches	.2	1.5	2.8	4.5	7.0	67.5	16.5
11845	Subsoil of 11844	Impervious silty loam, 6 to 25 inches.	.3	2.4	6.3	9.7	13.6	55.9	11.5
11847	Subsoil of 11846	Impervious silty loam, 8 to 24 inches.	.0	.6	1.7	5.0	11.6	63.2	17.5

SHARKEY CLAY.

The Sharkey clay covers a comparatively small proportion of the Neosho bottoms, and is consequently not a great factor in the agriculture of the area. The soil consists of a black clay, 0 to 10 inches deep, stiff, waxy, and tenacious. When dry it becomes very hard. cracks to some depth, and is very difficult to plow, while if plowed when too wet it bakes to such an extent that any further preparation for seeding it almost impossible. It is best to choose the intermediate condition, if possible, and plow in the fall or early winter instead of in the spring. When this is done the soil becomes more loamy, is easier to cultivate, and maintains a much higher moisture content during the growing season.

The subsoil, from 10 to 36 inches, is a stiff, waxy, and impervious clay, somewhat lighter in color than the soil, and slightly mottled with yellow, the mottling becoming more prominent with depth, or as the organic matter decreases from above, and often grading into a uniform drab color at a depth of 30 inches.

Occupying as it does the lowest areas in the river bottom, and being in the part of the bottom most distant from the river, the drainage of the type is naturally very poor. In addition to this, much water is usually received from the adjoining upland slopes. Floods of any consequence overflow most of the type, and much water remains after their subsidence, unless sloughs or artificial ditches afford means for its escape. Some parts of the type, occurring on slightly higher levels, constitute the strongest farming lands of the area. Drainage would materially benefit the type as a whole, but owing to the great uncertainty of crops on account of floods there is little disposition on the part of the owners to expend much money for this improvement.

The Sharkey clay is an alluvial deposit, and is formed principally from the finer particles deposited where the current during the time of overflow is very slow or entirely checked.

Where sufficiently drained this soil is excellently adapted to wheat, large yields of which have been produced. Were it not for the danger of loss by floods, it would undoubtedly be the best wheat soil of the area. Although not typically an ideal corn soil, the farmers often realize from 40 to 50 bushels per acre, and sometimes when the season is favorable this yield is exceeded. The soil remains too wet and warms up too late for the best results with oats.

The following table shows the results of mechanical analyses of typical samples of the Sharkey clay:

Mechanical analyses of Sharkey clay.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11867	5 miles S. of Humboldt.	Clay, 0 to 8 inches	0.0	0.2	0.4	2.7	2.7	54.3	39.6
11869	3 miles NW. of Iola	Black clay, 0 to 8 inches	.1	.4	.6	2.6	2.1	54.1	40.0
11870	Subsoil of 11869	Gray clay, 8 to 36 inches	.0	.4	.5	2.2	2.4	56.5	38.0
11868	Subsoil of 11867	Clay, 8 to 36 inches	.1	.4	.9	5.8	4.4	47.8	40.5

SEDGWICK GRAVELLY LOAM.

The Sedgwick gravelly loam, which is of rather limited extent in the area, is not well suited to general farming. The surface soil, to a depth of 8 inches, consists of a very dark to black loam, containing from 10 to 50 per cent of rounded and worn chert fragments of a reddish tinge. The subsoil, from 8 to 36 inches, is a very stiff, tenacious red clay, in which small quantities of the same gravel usually occur. The gravel content of both soil and subsoil varies greatly. In many instances it is impossible to bore more than 5 or 6 inches, while again there is not enough gravel to interfere with cultivation.

This type is almost wholly confined to the northwestern part of the county, and is somewhat patchy in its occurrence. It is found on knobs and ridges, which rise from 5 to 30 feet above the general level, presenting thus a rolling topography and affording an excellent surface drainage. The gravel in the soil also permits ready subdrainage. This is a very desirable feature in a wet year, but in many seasons crops suffer greatly from drought and often fail absolutely.

The gravel seems to be deposited above the other formations, and is mixed with the soils derived therefrom. It has greatly protected the surface from erosion. In almost all instances the soil is composed largely of material derived from limestone, together with some slight admixture of the products of disintegrated and decomposed chert. The occurrence of this gravel formation is somewhat peculiar, and geologists offer no very satisfactory theory for its deposition. The surrounding soil type is generally the Sedgwick clay loam, but it is occasionally the Oswego silt loam, and in such instances the interstitial soil becomes more silty, though the type is otherwise the same.

The Sedgwick gravelly loam as a whole is best adapted to pasture, but where the proportion of stone is not excessive corn is successfully grown, especially in wet seasons, when as many as 50 bushels per acre have been produced, though the average is about 20 bushels or lower. Grapes, peaches, and a few other fruits would probably do well on the greater part of this soil. Flax has yielded from 6 to 8 bushels. Wheat and oats have been grown but little.

The following table shows the results of mechanical analyses of the fine earth of this soil:

Mechanical analyses of Sedgwick gravelly loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11842	5¼ miles NW. of Iola.	Silty loam, 0 to 12 inches.	1.6	1.2	0.7	1.2	5.2	61.5	28.2
11843	Subsoil of 11842	Clay, 12 to 30 inches.......	2.5	1.5	1.1	4.2	7.1	53.2	30.2

YAZOO LOAM.

The Yazoo loam is the most extensive of the bottom soils. Being an alluvial deposit, it varies somewhat in texture, being composed chiefly of silt, fine sand, and clay, in different proportions, although the first largely predominates. Near the streams quantities of fine sand and silt are usually greater, while farther back, and occasionally in strips marking old river channels, the soil contains more clay and becomes perceptibly heavier. A typical profile consists of a loose, friable loam or silt loam to an average depth of 10 inches, dark to dark brown in color, and containing a small amount of fine sand. Below this to a depth of 36 inches is found a dark-gray to dark yellowish-gray silt and fine sandy loam, permeable and easily penetrated by all deep-rooted crops. This is a very productive soil, and its texture is such as to need no special treatment other than good cultivation. During the last few years the most serious drawback to crop production on the type has been the floods, with which it seems impossible to deal successfully. These, however, are said to be the exception rather than the rule.

The Yazoo loam occupies the greater part of the broad Neosho bottom, being found almost invariably near the river and consequently on the highest portions, from which it slopes very slightly back toward the uplands, more or less continuously, and in many instances coming directly into contact with the upland soils. It likewise occurs in narrower strips along some of the creeks and smaller streams, and here presents somewhat wider variations from the true river type. Along the smaller tributaries floods are less injurious, since they subside more quickly. For all ordinary rainfall the drainage of the type as a whole is fairly good, but in many places artificial drainage is necessary on account of the level or slightly depressed surface of such areas.

This type of soil is naturally well adapted to corn, and, aside from the liability to damage by floods, is the best soil for this crop in the area. Very large yields have been produced, but it is doubtful whether for a long series of years the average will prove much above that of the upland types. With the same exception, it is equally as well adapted to alfalfa, but only on the highest areas along the creeks can this crop expect to escape drowning out. Wheat, oats, and all the other crops of the area do exceptionally well in favorable seasons.

The following table shows the results of mechanical analyses of both soil and subsoil of this type:

Mechanical analyses of Yazoo loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11871	3 miles SW. of Iola..	Silty loam, 0 to 14 inches.	0.0	0.1	0.1	2.0	11.2	69.8	16.2
11873	2¼ miles SW. of Humboldt.	Silty loam, 0 to 6 inches..	.0	.2	.2	1.7	5.9	71.5	20.2
11872	Subsoil of 11871	Silty loam, 14 to 36 inches.	.0	.0	.1	1.7	8.2	74.0	15.8
11874	Subsoil of 11873	Silty clay loam, 6 to 36 inches.	.0	.0	.1	1.5	3.8	68.4	25.6

OSWEGO FINE SANDY LOAM.

The Oswego fine sandy loam, locally known as "sandstone soil," covers a comparatively small area in Allen County, but is very well suited to general agricultural purposes. The soil to a depth of 12 inches is a yellowish to reddish-brown fine sandy loam, or loam the sand content of which, varying from 30 to 45 per cent, is of the fine and very fine grades, and of a peculiarly sparkling appearance. From 12 to 36 inches is found a yellow fine sandy loam, or loam usually somewhat heavier and more compact than the soil, and often containing fragments of partially decomposed sandstone and arenaceous shale at from 25 to 36 inches below the surface. Where these rock fragments occur a red mottled or spotted color is common, and their presence likewise gives rise to a looser, more open structure in the lower portion of the soil profile. Under cultivation this soil retains a loose, friable condition with less attention than any of the other residual types, and it can also be plowed when in a relatively wet condition without much danger of puddling. It warms up and dries off early in the spring, permitting cultivation earlier than in the case of the other soils.

It is distinctly an upland type and occurs in rather broken and disconnected areas, which are confined principally to the southeastern and eastern portions of the area, occupying rounded knobs and elongated ridges, together with their slopes and the depressions between. Owing to the comparative thinness of the layers of sandstone and arenaceous shale from which it is derived, a depression of any great width or depth will usually show another type of soil. Because of its rolling topography and porous subsoil, crops suffer very little in times of excessive rainfall. On the other hand, with thorough and frequent surface cultivation it does not lack moisture in times of drought.

All the general farm crops of the area are successfully grown, but the type is best adapted to corn, broom corn, potatoes, truck, and small fruits, and on the more sandy phases to sweet potatoes. The average yields of the principal crops grown are about as follows: Corn, 22 bushels; broom corn, one-third of a ton; wheat, 16 bushels, and oats, 25 bushels per acre.

The following table shows the results of mechanical analyses of typical samples of this soil:

Mechanical analyses of Oswego fine sandy loam.

No.	Locality	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11849	8¼ miles SE. of Humboldt.	Silty sandy loam, 0 to 12 inches.	0.4	1.0	0.4	4.8	25.5	55.9	12.0
11851	2 miles W. of Elsmore.	Fine sandy loam, 0 to 12 inches.	.1	.3	.6	10.9	36.6	37.9	13.2
11852	Subsoil of 11851	Fine sandy loam, 12 to 36 inches.	.3	.7	.9	13.4	32.0	34.5	18.1
11850	Subsoil of 11849	Loam, 12 to 36 inches.....	.8	1.8	.6	3.8	15.2	52.1	26.1

YAZOO CLAY.

Intermediate between the Yazoo loam and Sharkey clay of the bottoms is found the Yazoo clay. It is a somewhat heavier type of soil than the Yazoo loam and more loamy than the Sharkey clay. The upper 6 inches is a dark clay loam, which sun-cracks when dry, but is loose and friable when reasonably moist and well cultivated, with a tendency to be sticky when wet. The subsoil, from 8 to 36 inches, contains less organic matter than the surface soil and is a dark-gray and drab mottled clay or silty clay, which becomes a dark drab at lower depths.

The type as a whole covers a comparatively small territory, and aside from the danger of damage from floods is a very valuable and productive soil. Some attempts have been made at diking, which so far have proven inadequate. A few areas are located quite favorably for this, but would require a bank from 5 to 12 feet high for absolute safety.

This soil is an alluvial deposit, lying in the Neosho bottoms, between the Yazoo loam and the Sharkey clay of the uplands. From year to year thin layers of sediment are still being deposited by the river in its overflows, and large quantities of organic matter are continually added in the same way. Like the other bottom soils, it has a level topography and rather poor surface drainage. Tiling would be very beneficial, but, as with the other bottom types, the most serious drawback. for the past few years has been that of overflow.

In adaptation to crops and their yields the type is very much like the Sharkey clay, being best suited to wheat, though capable of producing large yields of corn during favorable seasons.

The following table shows the results of mechanical analyses of typical samples of the Yazoo clay:

Mechanical analyses of Yazoo clay.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11875	2 miles NW. of Humboldt.	Clay loam, 0 to 8 inches	0.1	0.2	0.2	2.1	6.1	58.7	32.4
11876	Subsoil of 11875	Gray clay, 8 to 36 inches	.0	.4	.5	3.0	4.6	48.7	42.4

YAZOO SANDY LOAM.

Only a very small portion of the bottoms of the area can be classed under this type, and because of its limited extent no samples were collected for analysis.

ROUGH STONY LAND.

Adjoining the areas of rock outcrop and in various places associated with the Sedgwick clay loam, occur areas more or less rough and stony, which, although not so barren as to be worthless, can be used for pasture only.

ROCK OUTCROP.

A few areas, amounting in the aggregate to a little more than 1 square mile, are classified as rock outcrop. Such areas are of absolutely no agricultural value.

SPECIAL PROBLEMS.

Of the problems confronting the farmers of the upland areas in Allen County, that of the intractable subsoil of the Oswego silt loam and other important types, locally known as "hardpan," concerns the greatest number and is the most serious and difficult to deal with. Owing to its wide distribution, this stiff, compact, and impervious subsoil, and the consequent unfavorable moisture conditions, reduce materially the crop production in the county. In its prevailing occurrence it approaches very nearly a typical hardpan, while in other instances, though departing somewhat from the characteristic structure of hardpan, it still is close, massive, and sufficiently impervious to interfere seriously with the movement of water, either when the need is for subdrainage or when, owing to drought, there is necessity for capillary movement of the deeper subsoil water to within the root zone of the growing crops.

The season of 1904, being very wet until the middle of July, afforded an excellent opportunity to study the conditions consequent upon an excess of moisture. Despite the fact that the fields were generally rolling and apparently had an excellent natural drainage, the effects were very marked, not only in the depressions, but on the ridges and slopes as well. Corn took on a yellow and scalded appearance, made a stunted growth, tasseled early, and gave very light yields. In short, it was "water killed," regardless of its location, whether on the higher elevations or slopes, possibly suffering most in the latter position on account of the seepage from higher levels along the impervious subsoil stratum.

It may be stated in general that whatever deepens the soil above and loosens or flocculates the subsoil below will aid in promoting subdrainage, and only to the extent to which this is accomplished can beneficial results be expected. In the progress of the survey some excellent examples of the effects of deep plowing alone were observed. A few fields plowed to a depth of 10 inches suffered but little, while on the same soil and slope in adjoining fields, where the plowing had been much shallower, the crop was almost an entire failure. In past years subsoiling has been found to give good results, but owing to the labor and expense which it requires this practice has been abandoned.

In addition to deep plowing and subsoiling, and to make the results more certain and lasting, tile drainage would probably prove very beneficial, even if the drains were laid at wide intervals and only with a view to cutting off the seepage from the slopes and ridges. Underdrainage would tend also to keep the subsoil more open by promoting better aeration, but owing to the character of the subsoil materials thorough subdrainage would doubtless be very expensive and might not be economical at present. Some thorough and practical experimentation along these lines should be made to determine the efficiency of drains and the cost of laying them under a system designed for the fullest possible amelioration of the impervious condition of this subsoil.

The treatment that will give the best results during excess of moisture will also prove the best in seasons of drought, for the conditions that prevent the downward percolation of water likewise prevent its capillary rise from below.

Unlike the drainage problem in some parts of the country, the matter in Allen County is not one calling for cooperative effort, but can be taken up by the farmers individually.

AGRICULTURAL METHODS.

There are many unimproved farms in Allen County. A disregard of the needs of the soil, injudicious cultivation, and unsystematic cropping have done much to reduce the productiveness of a large part of the land in the area. The more progressive farmers, however, are beginning to practice better methods, and their action may influence others to adopt a more intelligent system.

The character of the soils of the greater part of the area, or almost the entire upland and second bottom portion, is such that a slight increase of humus or organic matter proves highly beneficial in many ways. In fact, in order to get good results with the soils found here, it is necessary to maintain organic matter in abundance. When it has been reduced by continuous cropping without rotation, as has been the common practice in the area, the main crop being corn, the soils become lighter in color and run together into a compact mass which admits water slowly and permits it to evaporate readily.

A systematic rotation of crops should be at once initiated, in which clover and other legumes should have a regular place; these should be plowed under to a good depth and thoroughly incorporated in the soil in the late summer or fall, before planting to corn the following spring. Such a procedure would tend greatly to overcome one of the very objectionable features found where cultivation has been carried on for several years.

Considering the beneficial effects of manure in supplying both organic matter and plant food, and the length of time these effects are manifest on these soils, too little attention is given toward increasing the supply, and too much neglect is shown in making a proper use of the manure that is produced. Nearly every farmer keeps a small number of live stock, but there is great need of increasing the number so that certain crops and roughage may better be turned into manure, and more of it produced. If too much of the prairie pasture has been "broken out," it should be replaced by redtop and bluegrass, and, in general, an effort should be made to reduce the acreage of crops under cultivation, and to increase the yields by employing better methods, devoting more land to grass for summer pasturage.

A careful study of the upland and second bottom soils, the ones which seem to require the most careful management, together with the climatic conditions of the area, suggests the following as possibly the best method for successfully growing corn: Plow the soil to a good depth—10 inches if possible—in the fall or late summer and disk as soon as it is advisable to go on the fields in the spring, in order to check evaporation. If heavy rains follow, repeat the process and reduce to perfect tilth before planting. As soon as possible after the plants are up begin level surface cultivation, and keep it up at regular intervals till late in the growing season, the later the better if kept shallow and the surface level. If it is impossible to break the soil in the fall or summer, it should still be plowed deep, also thoroughly disked and harrowed before planting, and if necessary, rolled, to be followed by harrowing. Fall plowing and early sowing are to be recommended for oats.

In the production of wheat the soil should be plowed early in the summer, somewhat shallower than for corn, and partly reduced to a condition suitable for seeding. A few days after each succeeding rain, if they are not too numerous, it should be harrowed lightly. In this way a supply of moisture can be stored up which will enable the crop to start on a vigorous growth at once regardless of the dry weather which may set in about the time of sowing. When the soil can not be plowed early, a roller should be used, before drilling, to form a firm seed bed. The judicious use of commercial fertilizer is not to be discouraged, but the farmers should by no means discard barnyard and green manures, which are so essentially needed in soils whose peculiar texture requires a large amount of organic matter to maintain a mechanical condition suitable to crop growth.

AGRICULTURAL CONDITIONS.

Agriculture in somewhat varied forms has been the chief pursuit of the inhabitants of Allen County since its settlement. Of recent years it has been growing more general in its scope, and some material progress has been made. Land has increased in value, adding greatly to the general wealth of the farming classes. While there are many evidences about the average farm that would indicate a not very prosperous condition, the landowning class may be considered as in very good financial circumstances. The modern country home, with adequate barns and other farm buildings, is seen here and there, but these are the exception rather than the general rule, and their number varies somewhat in different parts of the county.

Only about 40 per cent of the farms are operated by the owners. Renting is thus seen to be quite prevalent, and it is probably on the increase. Large oil and gas, smelter, and cement companies have recently bought up adjoining farms in large tracts for the furtherance of their interests, and they rent them out to a rather poor class of tenants, little care being taken to improve their agricultural value. Many individual owners also make a practice of renting their farms. A share of the crop is usually given, which in the case of corn is usually one-third in the shock, and in the case of wheat and other grains one-half. Meadows of native grass are generally rented for cash at $1 an acre. Farming land under the cash-rental system brings from $1 to $1.50 an acre. Aside from the larger tracts, the average farm consists of about 160 acres.

A great hindrance to agricultural operations in the county is the peculiar labor conditions which exist. The other industries employ such large numbers of men at better wages than the farmer can afford to pay that it has become difficult to hire men to do ordinary farm work. The average price paid a farm hand is $20 a month. During wheat, hay, and broom-corn harvest there is a good demand for hands at $1.50 a day.

Corn, native hay, oats, wheat, millet, and broom corn constitute the chief crops of the area. Corn is grown most extensively, but the acreage in other crops, more especially wheat, is being increased. Broom corn is confined principally to the southeastern portion of the county, where community cooperation of labor is most practicable, this being necessary under present conditions. Kafir corn and sorghum are sown to some extent for forage. Clover, timothy, redtop, and flax are crops of some importance. The acreage of flax is decreasing, as its continued cultivation has rendered many fields unfit for its profitable production. By applying manures and growing other crops for a few years, fair yields may again be had on the same land. As to the value of clover, timothy, and redtop, compared with that of the native grass, there is a difference of opinion among farmers. Many prefer the native grass both for pasture and hay, but those who have given the matter a thorough trial find that by a liberal seeding and thorough preparation of the soil a good stand of either of the others may be easily obtained, and that when this is accomplished they are much to be preferred to meet the general demands of the farm. An acre of native grass yields from 1 to 1½ tons of hay per acre, which is best suited to horses, while a fairly good stand of clover and timothy will yield from 1½ to 2 tons of hay having a greater value for general feeding purposes. Good timothy meadows rent for from $1.50 to $2 an acre, whereas native grass meadows generally rent for $1. The yield of redtop hay is about the same as that of clover and timothy, but its chief value lies in pasture, one acre being equal to two of the native grass for this purpose.

Throughout the county, year after year, corn will average from 18 to 22 bushels per acre; wheat, 12 to 18; millet, 25 to 35 of seed; Kafir corn, 30 to 35 of seed and about 3 tons of roughage; and broom corn, one-fourth to one-third of a ton of straw. The average price of this straw for the last few years has been about $100 a ton.

Two lines of railroad pass through the county from north to south; another from east to west, with a branch line touching the northwest corner; and another crosses the southwestern part of the county. These several railroads afford ten shipping points in the county, and furnish direct connections with Kansas City and St. Louis, the principal markets for the products of the area.

SOIL SURVEY OF THE GARDEN CITY AREA, KANSAS.

By **JAMES L. BURGESS** and **GEORGE N. COFFEY.**

LOCATION AND BOUNDARIES OF THE AREA.

The Garden City area is situated in the southwestern part of the State of Kansas. The area surveyed lies between the parallels of 37° 49′ 23″ and 38° north latitude and the meridians of 100° 30′ and 101° west longitude. Its southern boundary is the fifth standard parallel, and the fourth guide meridian passes through Garden City.

The area embraces 227 square miles in the southwestern part of Finney County, and 108 square miles of the northwestern part of Gray County, making a total area of 335 square miles. It lies in what is known as the semiarid belt of the Middle West, and includes a large area of the sand-dune region that lies south of the Arkansas River.

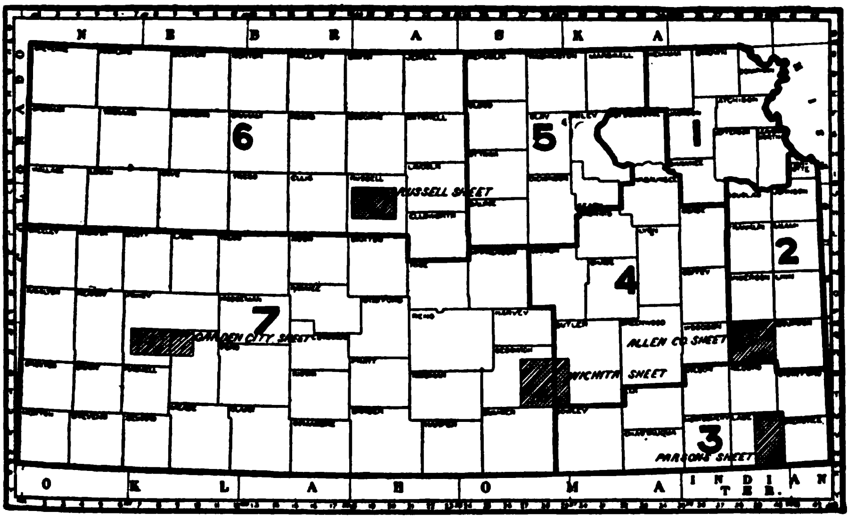

FIG. 38.—Sketch map showing the location of the Garden City area, Kansas.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

In 1878 William and James R. Fulton came from Ohio and located claims where Garden City now stands. These were the first white settlers in what is now Finney County, and their dwelling house, to-only houses in the county at that time. The Atchison, Topeka and Santa Fe Railway Company had just completed its road and opened the way for immigration. Countless herds of buffalo then roamed over the plains. The old Santa Fe trail, over which travel used to pass from east to west prior to the advent of the railroad, ran through the present town of Garden City. This town was incorporated in 1885.

The main interest in the area at this time was stock raising, and this has continued to be so to the present day. A few good wheat crops were raised in the early days of settlement, but the people became inclined to make their living from the grass of the plains and general farming was neglected. Irrigation was not thought necessary, and what little was done was in the way of an experiment. In 1879 the Garden City Canal was constructed and some land irrigated from it. As intimated above, crops of wheat, corn, barley, oats, and rye were raised in the early days of the settlement of the county, but the climate seemed to favor stock raising and the production of forage crops became all-important.

In 1885 the " boom " came. Allured by the hope of obtaining a homestead in this part of the West, thousands rushed to western Kansas, where a few favored seasons had produced abundant crops. The town site enlarged greatly, and town property sold for what would now be considered fabulous prices. Every quarter section of land for miles around had a house on it. A reaction followed. Failure came, not because the land was poor, but because the people who came did not understand the facts of soil and climate that exist in this part of the West. They attempted to introduce eastern methods into western conditions; they tried to farm the semiarid plains according to ideals brought with them from the humid belt. Consequently, those who were more easily discouraged returned home and left their claims unpatented, thinking the country had nothing to offer them, and it was only a few months until everybody wanted to sell and nobody wanted to buy. Most of those who stayed and fitted their practices to existing conditions have good homes and are prospering. The tide of immigration from the East has not been entirely cut off by the reaction that followed the " boom days," and farm lands are being gradually bought up and homes erected. Irrigation systems have been put in; the sugar-beet and durum-wheat industries are just now emerging from the experimental stage; the stock industry is in a fair state of development, and all lines of agriculture to which the soil and climate are adapted hold out inducements to the farmer who is willing to inform himself as to the best methods of soil culture to be practiced in this part of the West.

CLIMATE.

The Garden City area is wholly within that part of the Great Plains region characterized as subhumid. The climate is variable from humid to arid, but in the mean annual precipitation there is a marked deficiency. This part of the Great Plains is one of droughts; not of perpetual droughts, since there are humid intervals in short periods of groups of years; but the mean annual fall is below what is required for successful agriculture. Among the periodic variations, those of marked deficiency have the longer duration. Yet the humid intervals have enabled the pioneer to achieve a result that encouraged him to believe that the climatic conditions of the country were undergoing a permanent change. The records of the precipitation within this section, extending over a quarter of a century, disclose several of these humid periods, always offset, however, by periods of almost desert dryness, and indicate in the long run climatic stability.

The "boom days" in 1885 were caused by a succession of these humid years. For example, during the five years following 1880 the rainfall at Dodge City, 50 miles east of Garden City, averaged 6.1 inches during May, 3.4 inches during June, and 4.6 inches during July. The next five years are shown by the records to be years of exceeding dryness as compared with those that preceded them, resulting in abandoned farms, abandoned homes, and an almost abandoned town. There are few areas where a careful study of climatic conditions may bring greater results to the prospective purchaser.

Records of a quarter of a century show a uniform decline in precipitation across the Great Plains region westward. At Garden City the annual rainfall is about 19.81 inches, while evaporation is far in excess of this. At Dodge City the evaporation is over 54 inches annually, and while no records seem to have been kept here, it is certain that the evaporation in the Garden City areas is as great as it is at Dodge City.

The wind movement across this area is quite rapid, especially in March, April, July, and October. The records at Dodge City, taken hourly during 1897, show the average rate of wind movement for that year to be a little more than 10 miles an hour. As Dodge City is only 50 miles to the east, it is reasonable to suppose that these figures indicate quite closely the wind movement at Garden City.

While it is true that the rainfall here is quite as great as it is in the Dakotas, in the same longitude, it usually comes in the form of cloudbursts and quickly-passing thundershowers, and most of it runs off before it has time to sink into the soil. This fact emphasizes the importance and necessity of some method of cultivation by which the soil shall be made to store these storm waters and save them for crop production.

As the amount of precipitation has such an important bearing upon the agriculture of the area, and varies so much from year to year, the records at Garden City from 1897 to 1903, inclusive, are given in the following table:

Actual precipitation at Garden City, Kans., from 1897 to 1903, inclusive.

Month.	Year.						
	1897.	1898.	1899.	1900.	1901.	1902.	1903.
	Inches.	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*	*Inches.*
January	......	1.55	0.35	0.15	0.20	0.25	0.25
February	2.33	.00	1.18	.88	.55	.87	4.45
March	.19	.50	1.30	1.22	2.20	2.46	.70
April	2.09	.97	1.00	5.20	3.90	.70	5.10
May	.61	6.49	.42	2.05	1.20	6.26	1.49
June	3.19	6.89	4.40	2.79	1.30	2.43	2.83
July	3.49	2.59	6.21	2.18	1.48	.98	.77
August	5.80	2.04	1.00	.80	2.03	.88	3.65
September	.83	4.24	1.93	3.10	4.57	1.00	.35
October	1.78	.43	.75	.52	.60	2.62	.40
November	Tr.	1.55	1.26	Tr.	.00	.20	.40
December	.50	2.00	.78	.40	.31	1.00	.25
Total	20.31	28.75	20.58	19.29	18.34	19.65	20.64

The following table shows the normal monthly and annual temperature and precipitation at three Weather Bureau stations—Lakin, Garden City, and Dodge City. The former is about 20 miles west and the latter 50 miles east of Garden City. The records on which the normals are based cover periods of thirteen, eight, and twenty-nine years, respectively.

Normal monthly and annual temperature and precipitation.

Month.	Garden City.		Lakin.		Dodge City.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	°*F.*	*Inches.*	°*F.*	*Inches.*	°*F.*	*Inches.*
January	30.0	0.58	29.8	0.22	26.6	0.44
February	28.9	.99	31.4	.95	31.8	.63
March	41.8	.54	41.5	.63	41.6	.96
April	55.5	1.50	53.3	1.57	53.7	1.56
May	65.8	2.04	63.3	1.80	62.9	3.19
June	73.0	4.85	72.1	2.10	72.6	3.34
July	76.2	3.71	78.0	2.00	77.6	3.11
August	74.8	2.57	76.0	2.07	75.2	2.86
September	69.0	1.47	69.1	1.52	67.6	1.35
October	54.9	.68	57.0	1.01	55.1	1.20
November	40.8	.51	42.2	.20	40.2	.49
December	30.7	.92	32.2	.60	32.6	.63
Year	53.4	19.81	53.8	14.67	53.1	19.90

region in the semiarid belt, rises rather high during the day and falls comparatively low at night. This fact precludes the growth of such plants as flourish in districts where warm, moist nights prevail during the growing season. Killing frosts have been known to occur as late as May 26 and as early as September 7. The average, however, permits a growing season of about five months without serious frosts. The average dates of occurrence are April 27 and October 3.

While the extremes of heat and cold are quite pronounced in this area, the dry air and great rate of evaporation cause these extreme conditions not to be felt seriously by either man or beast. Many times the thermometer may fall as much as 20° or 30° below zero during the winter months, yet the cattle on the prairies that enter on the winter in good shape live through these periods without more shelter than a wind-break and are apparently unharmed.

PHYSIOGRAPHY AND GEOLOGY.

The Garden City area is located in the region known as the Great Plains. The surface features are, in general, those of a broad, gently rolling plain, through which the Arkansas River has carved out a valley from 1 to 3 miles in width and from 40 to 150 feet below the general level of the uplands. This stream flows diagonally across the area from northwest to southeast, and divides it into two almost equal parts. The elevation where the river enters the northwestern part of the area is 2,860 feet above sea level, and this decreases to about 2,675 feet where it leaves the southeast corner, giving a fall for this stream of about 6½ feet to the mile. There are a few points in the area that fall little short of 3,000 feet, but the average elevation is probably about 2,810 feet above tide level.

The valley is about 2½ miles wide at Garden City, and increases west of this place to as much as 3 miles. To the east it narrows rapidly, until, at the Point of Rocks, it is not more than 1 mile wide. From the Point of Rocks to the eastern boundary of the survey it has an average width of about 1½ miles. The river valley is comparatively level. There are a few local depressions and other irregularities of surface, caused by the shifting of the channel. These irregularities give rise to a first and a second bottom along most of its course in the area. Most of the river bottom is on the north side of the river, but there is a considerable stretch of first-bottom land on the south side of the river, just south of Sherlock, and south and west of Pierceville. The width of the first-bottom land varies all along the course of the river, narrowing and widening with the shifting of the channel during flood time. It is seldom, however, more than one-half mile in width.

About 2 miles east of Garden City is a valley known as the "White Woman Valley," running from the river northward through the northern boundary of the area. This old stream channel has a rise of about 8 feet to the mile, with quite gentle bluff lines. It is from one-fourth to one-half mile wide, and is now covered with heavy soil.

Beginning about 5 miles east of Garden City, and extending beyond the eastern boundary of the area, the bluffs on the north side of the river rise rather abruptly from 40 to 150 feet above the valley. These form the roughest and most broken part of the area. North and west of Garden City and on the south side of the river the bluffs are comparatively gentle.

The topography of the upland portion of the area north of the river is of a distinctly different type from that south of this stream. With the exception of a small area of sand dunes east of Garden City, the surface north of the river is level or gently rolling. Most of this level portion lies in the northeastern part of the area, principally in Gray County. There are about 120 square miles of these gently undulating prairies. In the extreme northeast corner the surface is somewhat broken by an eroded area that forms a part of the drainage basin of the Pawnee River. The prairies are dotted by many small depressions, but these have little influence upon the general character of the topography.

The topography of the uplands south of the river may be described in two words—"sand dunes." The height of these dunes varies from less than 5 feet to more than 60 feet, and will probably average as much as 30 feet. These dunes are usually larger and more numerous for the first 2 miles south of the river valley, but directly south of Garden City the country for a distance of 6 miles is a pile of sand hills. While practically all of the uplands south of the river is covered with sand, there are some areas which are comparatively smooth, and could be irrigated without much leveling if water were obtainable.

Early geologists mapped the strata in this area as Cretaceous, but later and more detailed investigation has brought to light facts that seem to justify their correlation with the Tertiary. Nearly the whole of the area north of the river is covered by what Mr. Hay[a] calls the Tertiary marl. He describes it as not unlike the loess of the Missouri Valley. It appears to be practically identical with the loess in Nebraska, Iowa, Missouri, Illinois, and that part of the West generally where the loess is most typically developed.

The marl in this area is composed of a small percentage of sand, a large percentage of silt, and some clay, and usually contains a relatively large percentage of lime and gypsum. In places it is sometimes difficult to distinguish between the Plains marl and the Tertiary grit, which lies below or at a lower level, but these places generally mark surface boundary lines between the two formations. The marl is of a uniform buff color, contains chalky nodules of irregular shape, and is everywhere of nearly the same texture.

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[a] Bul. 57, U. S. Geological Survey.

The Tertiary marl, or loess, as found in this part of the State, rests, as a rule, on eroded surfaces of the Permian, Jura-Trias, Cretaceous, and Tertiary grit formations. It forms the dead level of the high prairie between the greater rivers, thinning off toward their valleys, but following the slopes of their tributary dales.

The Tertiary grit, or " Mortar beds," as it is sometimes called, does not cover a large part of the area as an outcrop, but seems to underlie the whole area at varying depths. It is composed of sand, gravel, and pebbles, all of which are sometimes converted into a solid mass by the large percentage of lime which it usually contains. The extent and composition of the Tertiary grit seems to indicate that it has been the shingle of some old shore line, which has subsequently been buried beneath the Tertiary marl. The composition of the beds, together with their areal distribution, strongly suggests that it has been, in great measure at least, transferred from the mountain sides by the great floods that doubtless occurred during Tertiary time. The sand, gravel, and pebbles included in the grit are composed of feldspar, quartz, and various silicates of magnesia, iron, aluminum, etc., while interspersed through the mass of the rock are found mica, hornblende, and various other minerals found to-day in the Rocky Mountain region, from which it is undoubtedly derived.

The Alluvium or Recent deposits in the Arkansas Valley have a considerable areal extent. They are composed largely of arenaceous materials which have been brought down by the flood waters or liberated from the Tertiary grit by the winds and rains, aided by gravitational forces, and transported to lower levels. The Alluvium has, therefore, a local and a distant origin, and this fact gives it all the more value from an agricultural point of view.

The sand dunes south of the river are of recent origin. Dunes may now be seen that have recently been blown out of the river bed in the direction of the hills, while the main body of the hills, where not well protected by vegetation, gradually shifts with the fierce winds that in the early spring come from the northwest. The material of these dunes has doubtless come in part from the Tertiary grit formation and in part from the great body of sand that is gradually moving down the river.

SOILS.

The soils of this area, by reason of their geological and physiographic features, fall into two divisions, namely, the soils of the uplands and the soils of the valley. Those of the uplands are usually quite uniform, while those of the valley have been irregular in their deposition.

Nine types have been recognized and mapped according as they differed in texture, depth of soil and subsoil, drainage features, topographic position, and agricultural value. The soils of the immediate valley lie in a general parallelism to the present river bed, and show in their topographic features marked indications of recent fluvial action.

Below are given the name and extent of each of these several soil types:

Areas of different soils.

Soil.	Acres.	Per cent.
Dunesand	83,200	38.7
Marshall silt loam	77,120	35.9
Colorado sand	10,944	5.1
Laurel sandy loam	16,000	7.4
Rough stony land	8,768	4.1
Finney sandy loam	6,272	2.9
Laurel loam	8,704	4.0
Finney clay	2,240	1.0
Colorado adobe	1,472	.7
Total	214,720	

DUNESAND.

The Dunesand in the Garden City area, while almost a pure medium to fine sand, is sufficiently compact to hold itself in position, except in places where the vegetation has been removed. The sand is of a tawny or yellowish color, composed largely of quartz and feldspar, and is from a few feet to 60 feet deep. In the first 2 feet some organic matter is collecting and aiding in the production of weeds and grasses which are holding the sand in place. The greater portion of this type rests on what resembles, and is doubtless identical with, the Tertiary marl found north of the river.

The Dunesand covers nearly all of the area lying south of the river and a small percentage of that lying north of the river. Several well-defined dunes are found east of Garden City in secs. 17, 18, 19, 20, T. 24 S., R. 31 W.

The topographic features of the Dunesand contrast strikingly with those of the other types in this area. The dunes are from a few feet to 60 feet high; their crests are usually close together, separated by steep and narrow depressions that, in some places, assume the shape of miniature valleys. As a rule excellent water is obtained at from 50 to 60 feet below the surface when wells are sunk in the lower depressions. This water is practically free from alkali and quite pleasant to drink. This type of soil is well drained, but its moisture-holding capacity is becoming more and more pronounced as the growth of vegetation and the processes of weathering advance.

From 1 to 2 miles south of the river is found a depression where both the topography and the presence of waterworn gravel indicate a former river channel. From this old channel the present dunes were doubtless largely derived when the river swung northward and left the old bed to the action of drifting winds.

The chemical and mineral composition of the Dunesand agrees with that of the rocks from which it is derived, namely, the Tertiary grit, and the granites, and the various plutonic and volcanic eruptives of the distant western mountains. The sand is composed of quartz, feldspar, mica, iron oxide, and various other, but minor, constituents. The Dunesand was doubtless formed partly from the breaking down of the Tertiary grit and partly from the weathering of the rocks on the mountain sides at the headwaters of the Arkansas River. The sand from the latter source has undergone a greater and greater degree of comminution on its eastward march down the river and is now a medium and fine sand, the particles of which are more or less rounded.

The most important use to which the Dunesand is put at present is that of pasture land. It warms up easily and early in the spring and makes an excellent pasture in the summer and early autumn. Water sinks deeply and quickly into this sandy soil, the roots of grasses go down readily, and vegetation covers the sandy area soon after the first spring rains.

The Dunesand is now generally covered with vegetation, consisting principally of sage brush, Spanish dagger, and bunch, blue stem, and Redfield grasses, and is not now drifting perceptibly. When the vegetation is removed, however, the dunes are practically uncontrollable. From a very small beginning, where the plow has gone, some have lost whole farms. The sand being rather fine and of uniform size and rounded shape blows easily once the vegetation is removed. It is extremely unwise, therefore, as some have found by practical experience, to remove in any way the vegetation from the Dunesand. The effect of pasturing too many head of cattle on these dunes is the same as that produced by the use of the plow. Too much care can hardly be taken to encourage the growth of grass and trees on this type of soil.

The dunes found north of the river seem to be much older and of richer pasture than the dunes to the south.

Below are given the mechanical analyses of this type of soil:

Mechanical analyses of Dunesand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11116	NE. cor. sec. 13, T. 25 S., R. 33 W.	Fine to medium sand, 0 to 6 inches.	0.6	7.2	18.8	60.1	9.7	0.6	3.4
11115	SW. ¼ sec. 18, T. 25 S., R. 32 W.	Medium to fine sand, 0 to 72 inches.	1.1	8.0	12.2	56.2	16.6	1.0	4.6

COLORADO SAND.

The Colorado sand is a medium to fine sand of a light-brown or yellowish color. It is typically 6 feet deep, though it varies somewhat, becoming deeper or more shallow as it grades out into the surrounding Dunesand and sandy loam.

The Colorado sand is located in various parts of the area; but the greater portion is found south of the river in the Dunesand district. There are only two small areas north of the river, one about 2½ miles west and the other about 6 miles east of Garden City. Both these areas are cut by the railroad.

The surface of the Colorado sand is usually gently rolling and will require some expense in leveling before irrigation can be successfully practiced. Its topographic and textural drainage features are excellent. In mineralogical and chemical composition it is identical with the Dunesand.

The Colorado sand in this area has been derived from practically the same sources as those from which the Dunesand has been derived, namely, in part from the weathering of the Tertiary grit and in part from the weathered material in the upper drainage basin of the Arkansas River. It has since been blown about by the winds and is still in many places changing its surface features.

There is little or no farming done on this type in the present area. Sometimes a small plat is found on which sorghum is grown, but most of it is used as range land. The soil blows easily when disturbed, and, in the absence of irrigation, its cultivation will always be attended by more or less difficulty for this reason. Its texture is quite open, and should it be irrigated freely by the use of the flood waters its texture, and incidentally its water-holding capacity, would be favorably affected. This type contains no alkali.

The following table gives the results of mechanical analyses of the Colorado sand as it occurs in the Garden City area:

Mechanical analyses of Colorado sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11087	NE. ¼ sec. 15, T. 24 S., R. 33 W.	Brown loose sand, 0 to 72 inches.	0.7	8.7	16.1	43.9	21.6	2.8	6.1
11088	Cen. sec. 9, T. 24 S., R. 33 W.	Brown loamy sand, 0 to 18 inches.	2.4	11.7	19.5	40.4	15.3	3.8	6.9
11089	Subsoil of 11088	Yellow sand, 18 to 36 inches.	.6	7.1	15.2	46.1	20.6	4.2	6.0

MARSHALL SILT LOAM.

The Marshall silt loam is an extremely uniform type. The soil is a dark or chocolate brown silty loam, in which is found from 15 to 20 per cent of very fine sand. The particles of sand are all so fine that the soil retains the soft, smooth feel characteristics of a silty loam. The dark color usually extends to a depth of 16 to 18 inches, but the zone of weathering often reaches to 30 or 40 inches, depending upon the topography. The subsoil is a light-gray or grayish-yellow, very mealy, silty loam many feet in thickness. It was very dry and powdery at the time of the survey, because the rainfall had not been sufficient to wet the ground to any great depth. The less amount of rainfall here as compared with areas farther east, where the precipitation is greater, has caused much less weathering of the soil materials. There has been no leaching of the subsoil, and it therefore contains larger amounts of lime than is found in the type in humid regions.

A phase of this type, differing slightly from the typical upland soil, occurs in the second bottom, north of Garden City, and in the White Woman Valley. In this position it is usually underlain at about 6 feet by clay, and this fact, together with its topographic position, gives it a slightly different agricultural value.

The Marshall silt loam generally occupies the upland prairies, and is the major type found north of the river. It is especially well developed in the northeastern part of the survey, where it forms almost the exclusive soil type, dotted here and there with small areas of the Finney clay, which has been derived from it.

The surface of the Marshall silt loam is generally level, with sufficient relief for good drainage. The soil is highly retentive of moisture when a good mulch is kept on the surface, but because of its fine texture evaporation quickly relieves it of its moisture content when capillarity is unbroken. It is easily put in condition for crops and is an ideal soil for general agricultural purposes; but its elevated position above the water table, the light rainfall, and the present methods of soil management render general agriculture on this soil unprofitable, except in seasons of abnormal precipitation. This should by no means be true, since this is the best soil in the area and doubtless the best in this part of the State.

This soil is derived from the Plains marl, which, as has been stated already, is similar to the loess of Missouri and other central States. It seems probable that this is a wind-blown deposit, as it is uniformly composed of such materials as could easily be transported long distances by the wind. The zone of weathering has not yet reached more than 40 or 50 inches below the surface. Sections seen in old wells, "dugouts," and cellars expose the columnar structure and lime pipes so characteristic of the loess as found elsewhere. Roots extend to great depths, there being no hardpan or impervious stratum to obstruct the downward movement of either roots or water.

The Marshall silt loam is free from harmful amounts of alkali. The second-bottom phase contains a small percentage and there is a possibility of injury here from alkali unless proper methods are employed to prevent it. The soil and subsoil contain a considerable amount of lime, but there are no noticeable injurious effects on crops. This type is used largely as range land. There is a considerable amount of wheat grown in the northeastern part of the survey. Spelt and barley do well in favorable seasons, but the durum wheats will doubtless prove to be the most important cereal for this type of soil. This soil seems to be especially adapted to the growth of wheat, and the aridity of the climate strongly suggests the use of the durum varieties. Indeed, it has been proven conclusively that the durum varieties will give a good average yield during seasons in which the ordinary wheats prove to be an entire failure. The durum or macaroni wheat has recently been introduced by the Bureau of Plant Industry and the results have so far been quite favorable. As much as 25 bushels to the acre has been harvested from this soil, with an average of 10 bushels or less, depending on the season. Should the winter and spring precipitation be conserved by proper methods of cultivation, supplemented by an occasional cultivation of the wheat while small to prevent the formation of a crust and thus minimize evaporation, excellent yields of wheat could be obtained almost every year.

The surface of this soil is level enough to admit the use of all kinds of farm machinery, and with proper methods of soil management there is no doubt that this would become one of the great wheat soils of the West.

The following table gives mechanical analyses of this soil type:

Mechanical analyses of Marshall silt loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11108	SE. cor. sec. 27, T. 24 S., R. 31 W.	Brown silty loam, 0 to 16 inches.	0.2	0.8	0.7	3.7	20.2	54.2	19.9
11100	NE. ¼ sec. 8, T. 24 S, R. 31 W.	Brown silty loam, 0 to 24 inches.	.0	.3	.3	3.0	19.4	56.3	20.5
11181	Subsoil of 11100	Silty loam, 40 to 72 inches	.0	.1	.1	.6	14.6	63.7	20.4
11109	Subsoil of 11108	Yellow silt, 16 to 72 inches.	.1	1.3	1.1	4.0	15.2	56.6	21.5

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 11100, 2.9 per cent; No. 11108, 0.93 per cent; No. 11109, 8.8 per cent; No. 11181, 7.0 per cent.

FINNEY SANDY LOAM.

This is a medium to fine sandy loam of varying depth, ranging from a few inches to a few feet or more, and is always underlain by a silt loam, sometimes quite heavy and usually of great depth. The greatest development of this type is found on the uplands about 5 miles east of Garden City, and here the subsoil is quite uniform in texture and of very great depth. There is also a considerable area extending about 2½ miles northwest of Garden City. This area is finer than the upland areas and the subsoil is slightly heavier. This second-bottom phase is represented by samples Nos. 11092 and 11093.

The surface of this type is generally rolling, especially in the uplands, where small areas of sand are frequently found dotting the surface. That portion of this type found west of Garden City is comparatively level and may be irrigated with little expense for leveling. All of this soil has good drainage features, both textural and topographic, and by reason of its heavy subsoil it also has excellent moisture-holding capacity. This is evidenced by the observation that even the imperfect mulch formed by the disk drill in seeding this soil to sorghum kept the moisture beneath the surface long after the adjoining unbroken sod had been reduced to a powdery dryness.

The subsoil of the Finney sandy loam is a silt loam of a loesslike nature, while the soil is a sandy loam, very light in some places. The subsoil seems to have been deposited by wind or water action or both and the sand has since been blown over it. The origin of the sand is similar to the Dunesand, and this type represents areas where only a thin layer of sand was deposited over what is known as the "Plains marl," which occupies the uplands generally on the north side of the river. It has been some time since this deposition of sand took place, and subsequent weathering and plant growth have produced marked effects on the texture. This sandy soil contains a good percentage of clay and silt, and furnishes a habitat for a variety of weeds and grasses. It is free from alkali, except that the subsoil contains considerable lime, but this effects the surface only where this type merges into the Rough stony land.

With the exception of that portion which is found on the second bottom this type is generally used for range purposes, though an occasional field is found seeded to sorghum. On the second bottoms the Finney sandy loam is sometimes planted to alfalfa, which, on this soil, is more remunerative as a seed crop than as a forage crop. On the uplands as much as 2 tons of sorghum may be secured in favorable seasons.

The following table gives the results of mechanical analyses of this type, as found in the Garden City area:

Mechanical analyses of Finney sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11094	NW. cor. sec. 24, T. 24 S., R. 32 W.	Brown sandy loam, 0 to 24 inches.	0.8	10.5	14.9	24.9	16.8	20.0	12.0
11092	NE. ¼ sec. 10, T. 24 S., R. 33 W.	Fine sandy loam, 0 to 30 inches.	.4	3.0	6.5	23.2	26.4	27.8	12.4
11090	NW. ¼ sec. 24, T. 24 S., R. 32 W.	Yellow sandy loam, 0 to 20 inches.	.7	9.0	12.8	21.5	17.8	26.2	13.2
11095	Subsoil of 11094	Yellow silt, 24 to 72 inches.	.2	1.1	1.5	6.4	26.8	49.7	14.1
11093	Subsoil of 11092	Silty loam, 36 to 72 inches.	.2	1.1	.8	4.5	11.8	55.9	26.2

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 11093, 9.7 per cent; No. 11095, 7.8 per cent.

FINNEY CLAY.

The Finney clay is a dark tenacious clay soil, from 2 to 6 feet deep, overlying a heavy silt loam of great depth. When the soil becomes dry large cracks, often 2 inches or more in width, are formed.

It is found almost wholly in the upland prairies north of the river, occupying small local depressions, known as "buffalo wallows." The largest areas are found in the northeastern part of the survey, surrounded on all sides by the Marshall silt loam.

The soil has been deposited in these depressions by the wash from the surrounding slightly higher levels. It has at present little agricultural value in this area, and in a few places the presence of this stiff heavy clay soil presents some difficulty in the cultivation of the surrounding lighter soil. These spots are usually covered with a poor variety of swamp grass.

The following table gives the results of mechanical analyses of a soil and a subsoil of this type:

Mechanical analyses of Finney clay.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11105	NW. ¼ sec. 21, T. 24 S., R. 31 W.	Brown clay, 0 to 40 inches.	0.3	0.7	0.5	3.8	14.2	41.0	39.5
11106	Subsoil of 11105	Gray silty loam, 40 to 72 inches.	.1	.6	.3	1.3	13.7	59.3	24.7

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 11105, 0.52 per cent; No. 11106, 2.3 per cent.

ROUGH STONY LAND.

Rough stony land is usually a mass of sand, gravel, and pebbles, containing some clay and silt, all heavily charged with lime. It is of a light-gray color, due to the presence of large amounts of calcium. The zone of weathering has reached a depth of from 10 to 30 inches, below which is a compact, and more or less consolidated, conglomerate bed having a small percentage of fine earth. Where weathering is most advanced the material is little else than a mass of sand, gravel, and pebbles, in places containing some fine earth.

This type occupies the more precipitous bluff lines north of the river, and extends from near Garden City to the east boundary of the survey. Small areas are noted elsewhere, but the greatest extent is found along the bluffs, where erosion has cut and carved it into ravines of various sizes and shapes. The surface of the soil is very irregular and rough, so much so that most of it is unfit for agricultural purposes. It is derived from and is a part of the Tertiary grit noted by geologists as occupying the bluff lines in this and other parts of the Arkansas Valley. On the more level portions sorghum is sometimes grown, but the type as a whole is used as range land, and much of it is not worth even the cost of fencing for this purpose. Only an inferior and scant vegetation exists on it, except in some of the wider draws, where buffalo grass is found.

LAUREL SANDY LOAM.

This type of soil is composed of various grades of sand and gravel, mixed with a variable percentage of silt and clay. In some places the percentage of fine material is great enough to give the soil the characteristics of heavy sandy loam; then again this fine earth may be present in quantities so small as to give the soil approximately the texture of a gravelly sand. The different grades of material are so intermingled as to render impracticable any attempt to differentiate them into separate types of soil. The depth of the soil varies greatly, but it is nearly always underlain by a bed of sand and gravel at from 18 to 36 inches.

There are two phases of the Laurel sandy loam in this area occupying the first and second bottoms, respectively. The second bottom phase lies north of the river and is usually found about midway between the river and the bluff line, but in the eastern part of the survey it is found skirting the bluff line. Much of it occurs west of range 32 W. around and west of Garden City. The surface is usually gently rolling, with an occasional abrupt depression caused by the filling in of some former river channel, and in some places small arroyos finger out from the higher grounds adjoining.

The first-bottom phase lies parallel to and on both sides of the river and adjacent to it, except at a few points where either the Laurel loam or the Colorado sand supersedes it. It includes also the larger islands of the river. Sand ridges, covered with vegetation, frequently appear lying parallel to the course of the stream. Between the narrow ridges, strips of clay and silt are found. In fact, this phase of the type grades quickly from a clay in some places to almost pure sand in another, and, from the various textured materials composing it and thrown together by the shifting currents of the river, it closely resembles meadow.

With the exception of that portion of the type lying immediately under the bluff, the Laurel sandy loam is wholly of fluvial origin, representing a surface that has at different times been occupied by the river bed. The fact is emphasized by the presence of a bed of coarse sand and gravel at varying depths underlying all of the type found in the river bottom. The underlying sand and gravel is practically the same in appearance as that found in the present river channel. Much of the material in the first bottom has evidently been deposited by comparatively recent fluvial action, having been transported long distances from the west by the river during flood seasons. As the floods subsided the coarser particles were first deposited, while the fine materials, such as silt and clay, remained in suspension in the water left in the sloughs and pools, and were laid down on the coarser material beneath. The river occasionally overflows at various points and adds considerable silt and clay to the soil, the result being that the texture is gradually becoming finer and the soil stratum deeper. That portion of the type found along the bluff line has doubtless been formed from the weathering of the Tertiary grit or mortar beds found just above it. This weathered material has been carried by the sudden and heavy rains down into the lowlands and spread out in a sinuous line, reaching from near the White Woman Valley to the east boundary of the survey.

The Laurel sandy loam is practically free from harmful amounts of alkali, and only a few points are found where indications of alkali were pronounced, yet if irrigation should be practiced the heavier phases of the type might give some trouble. The remedy is discussed in the chapter on alkali. Judging from the sand and gravel contained in this soil, the principal minerals composing it are quartz and feldspar.

The second-bottom phase of this soil is generally so open that moisture either evaporates or passes readily down below the zone of root action before the plant can use it. The soil greatly needs more fine material, and this can be added by a free use of the sediment-laden flood waters. This phase of the type lies in a position quite favorable to irrigation, and the greater part of it lies under the ditch, but unfortunately many of the farmers do not take advantage of the opportunity afforded them for irrigation. Since it occupies such an important position in the agricultural development of the valley, the necessity for the use of the annual flood waters can not be too strongly urged. On the heavier phases fair crops of alfalfa, sorghum, sugar beets, Kafir corn, and macaroni wheat are sometimes harvested. Under favorable conditions of cultivation and moisture from 8 to 12 tons of beets, one-half to 1 ton of alfalfa hay, and 2 tons of sorghum or Kafir corn per acre can be produced, but the average yields are far below these figures. Vegetables seem to do well when sufficient water is applied, and it is not improbable that such crops as potatoes and cantaloupes would pay handsomely even in the light sandy phases if sufficient water can be obtained.

The first-bottom phase is at present used largely as range land and permanent meadow. It doubtless could be made to bring profitable returns if used for general agricultural purposes. The water table is too near the surface for the growth of alfalfa, but almost any shallow-rooted forage crop adapted to the climate would do well. With proper cultivation, there is little doubt that this soil would produce cantaloupes of excellent quality. Where the land is used for permanent pasture it would be advisable to give the surface a thorough disking and to sow alsike clover or some other pasture plant that will not be injured by the fluctuations of the water table.

The following table gives the results of mechanical analyses of the fine earth of the Laurel sandy loam:

Mechanical analyses of Laurel sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11085	NE. ¼ sec. 18, T. 24 S., R. 33 W.	Sandy loam, 0 to 15 inches.	1.0	8.9	13.6	32.6	19.1	12.7	11.6
11101	SW. ¼ sec. 2, T. 24 S., R. 33 W.	Brown fine sandy loam, 0 to 30 inches.	0.7	3.8	4.7	13.4	37.5	28.0	12.0
11114	SE. ¼ sec. 5, T. 24 S., R. 33 W.	Sandy loam, 0 to 36 inches.	1.2	7.0	10.7	28.6	23.0	14.6	15.0
11107	SW. ¼ of SW. ¼ sec. 4, T. 24 S., R. 33 W.	Brown sandy loam, 0 to 36 inches.	5.8	12.0	11.5	16.6	22.8	14.8	16.5
11086	Subsoil of 11085	Reddish sand, 15 to 36 inches.	12.7	28.5	21.5	17.8	9.6	5.5	4.3
11102	Subsoil of 11101	Coarse sandy loam, 30 to 40 inches.	3.1	10.6	15.7	27.8	14.1	9.9	18.7

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 11101, 5.2 per cent; No. 11102, 6.5 per cent; No. 11114, 0.95 per cent.

COLORADO ADOBE.

The first 3 to 5 inches of the soil of the Colorado adobe is a heavy medium to fine sandy loam of a dark or chocolate-brown color. There is also a small percentage of coarse sand and gravel, the latter having been brought up from the underlying gravel bed by prairie dogs, while the finer grades of sand have been deposited by the wind. In the section from 5 to 18 inches less sand and more silt and clay is present, giving a texture heavier and more nearly a clay loam. This layer has a very pronounced adobe structure, is very hard, and when crushed breaks into cubes. It is rather impervious to water. When heavy rains occur the water stands, until evaporated, in the "buffalo wallows" that dot the surface. This adobe stratum is in turn underlain by a rather heavy fine sandy loam of a lighter color, which becomes gradually lighter in texture with depth, until a bed of old river sand and gravel is reached at from 4 to 8 feet below the surface.

The greatest area of this type lies upon the second bottom in the northwest corner of the survey in secs. 4, 5, and 6, T. 24 S., R. 33 W., and in sec. 1, T. 24 S., R. 34 W. Other and smaller bodies are found at various points in the area, the most important of which lies in the White Woman Valley, east of Garden City, in secs. 7 and 10, T. 24 S., R. 32 W.

The surface of this soil is only slightly rolling, and is nearly level in most cases. The greater portion of it lies 8 or 15 feet above the water table. This, and the additional facts that its surface is slightly rolling, that its subsoil becomes lighter in texture with depth, and that it is underlain at about 50 inches by a bed of sand and gravel, tends to furnish this type with excellent drainage features.

The Colorado adobe owes its origin in great measure to river action, but has since been materially modified by weathering and by the wash of clayey material from the hillsides. There is some wind-blown sand on the surface, sufficient in amount to make a sandy loam that may be from 2 to 3 inches deep in some places. The material for the first 12 or 18 inches has undergone considerable weathering, and there is incorporated with it a considerable quantity of organic matter.

This type contains a small percentage of alkali. No serious trouble has as yet been experienced with it, but its presence indicates that the conditions might become troublesome should irrigation be practiced.

This "gumbo soil" will produce good crops of sorghum, wheat, and even alfalfa, if only enough water can be obtained. It needs deep plowing, proper tilth, an occasional saturation—say, two or three times a year—followed always by a good 3-inch mulch of loose dry soil, which must continually be maintained. With these conditions fulfilled there is no doubt that excellent crops can be obtained each year, whereas at present only moderate yields are secured in favorable seasons.

At present some sorghum, alfalfa, and Kafir corn are produced on this type, and a yield of from one-half to 1½ tons to the acre is secured, but when properly handled, the Colorado adobe will produce excellent alfalfa, beets, sorghum, and other crops that may be grown at this elevation.

The following table gives the results of mechanical analyses of this soil:

Mechanical analyses of Colorado adobe.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11110	SE. ¼ of NE. ¼ sec. 6, T. 24 S., R. 33 W.	Brown fine sandy loam, 0 to 5 inches.	2.7	5.2	4.1	11.4	27.0	32.8	16.6
11111	Subsoil of 11110	Heavy silty loam, 5 to 60 inches.	.8	1.7	2.1	8.5	15.1	45.4	26.4

LAUREL LOAM.

This type of soil, as found in the Garden City area, presents features varying somewhat according to its location. It is the best soil in the Arkansas Valley, and is especially well developed in that part of the valley lying immediately east and west of Garden City.

As a second-bottom type it is not found on elevations of more than 10 or 15 feet above the present river bed; hence the water table can always be reached by deep-rooted crops, such as alfalfa and clover. The surface is generally level, with just sufficient relief to give good drainage. The soil is a rather heavy dark-brown loam, becoming lighter in color with depth. It varies considerably, both in texture and depth of soil and subsoil. In some places the percentage of sand is rather large, but these areas are not of sufficient extent to have any marked effect on the agricultural value of the type. These variations are due largely to the mode of deposition. The subsoil is much more sandy and gravelly than the soil. Sometimes almost pure sand is found at from 30 to 36 inches, and the type is nearly always underlain by a bed of gravel at from 3 to 6 feet. As it appears in the valley, the soil seems to have a twofold origin. The lower portions show the former presence of the river channel, where the coarse sand and gravel are not unlike that found in the river bed of to-day. The upper portion has been formed by the occasional inundations of the river when it began to abandon its old channel and swing southward and by the washing in of silt and clay from the adjoining uplands.

Another phase of the Laurel loam occupies a portion of the first bottom on both sides of the river, usually occurring in long, narrow strips parallel with the course of the stream. The largest body is found on the north side of the river, extending a few miles east and west of Garden City. The soil varies from a dark-gray heavy sandy loam to a heavy silt loam, with only a small percentage of sand. The average depth of soil is about 12 inches, but its depth varies in places, owing to its irregular deposition by fluvial action and the occasional floodings to which it is subjected. It is underlain by an interstratified fine sand and silt of mottled reddish and gray color. As a result of deposition by the shifting currents of the river the depth of both soil and subsoil varies considerably, but it is always underlain at from 26 to 36 inches by a bed of waterworn gravel. As the subsoil is very porous, the soil is easily and quickly saturated and as easily dried out when the flood season is over. In places, however, the subsoil has sufficiently fine texture to lift the capillary water up from the water table, which is only from 4 to 6 feet below the surface during the dry season. Weathering and decaying plant remains have had a marked influence on the texture of the soil, and its composition is such as to render it an excellent soil for the growth of grasses and various other forage plants, except alfalfa, for which the water table is thought to be too near the surface. Where the soil is as much as 12 inches deep, good crops of beets, sorghum, and cantaloupes, no doubt, could be produced, although it is used at present principally as pasture and permanent meadow.

As before stated, the type as a whole is the best soil in the Arkansas Valley, the areas occupying the second bottom being the more valuable for agricultural purposes. Without irrigation alfalfa yields from one-half to 1½ tons per acre. By the aid of irrigation, using windmills, as much as 23 tons of sugar beets has been obtained from this soil. While the second-bottom phase is especially adapted to the growth of alfalfa and sugar beets, all other crops grown in the area, such as macaroni wheat, oats, spelt, rye, barley, millet, potatoes, etc., would doubtless give large yields on this soil. The texture is excellent, the moisture-holding capacity is ample, the subsoil is quite favorable to root growth, and the soil is well supplied with humus.

The following table gives the results of mechanical analyses of the soil and subsoil of the Laurel loam:

Mechanical analyses of Laurel loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11096	Sec. 22, T. 24 S., R. 32 W.	Dark-brown loam, 0 to 36 inches.	1.0	3.3	4.5	15.3	19.7	34.1	21.9
11103	SE. ¼ sec. 7, T. 24 S., R. 33 W.	Gray loam, 0 to 12 inches.	.4	2.7	5.5	17.5	23.9	27.4	22.4
11083	NE. ¼ sec. 21, T. 24 S., R. 32 W.	Dark heavy loam, 0 to 33 inches.	1.0	2.8	4.2	9.2	20.8	33.0	28.8
11097	Subsoil of 11096	Sand, 36 to 72 inches	3.6	11.1	14.5	43.8	17.6	4.4	5.0
11104	Subsoil of 11103	Gray sand, 12 to 36 inches.	1.2	7.0	13.6	36.9	25.7	10.6	5.1
11084	Subsoil of 11083	Yellow sand, 33 to 48 inches.	2.6	10.5	18.4	28.1	16.2	13.9	10.3

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 11083, 15.9 per cent; No. 11084, 4.0 per cent.

HARDPAN.

There is no typical hardpan in this area, but in the river valley there are local variations in both the Laurel loam and the Laurel sandy loam that have some of the characteristics of a hardpan. In the sandy loam it offers some resistance to the penetration of roots, but in the loam its chief evil lies in the resistance which it offers to the upward movement of capillary water from the subsoil. The soil is always found to contain much more moisture and to retain it longer on areas where this subsurface crust has been broken up. It has been formed, no doubt, by the light rains. These usually penetrate the soil from 1 to 18 inches, and carry lime and such other soluble material as may be in the soil down to lower depths, where, coming into contact with various other chemical constituents, certain silicates are formed—usually a soft limestone. This compact stratum is seldom found below 18 inches.

To correct this condition subsoiling is recommended, together with yearly saturation of the soil to greater depths. It is highly important in the bottom lands that capillarity be continuous from the water table, which is about 6 feet below the surface, to the zone of root growth above. With proper methods of cultivation this condition of soil texture is quite practicable on most of the first and second bottom lands, except possibly the more sandy areas. It is found, as would naturally be the case, that when a condition of continuous capillarity is maintained much smaller applications of irrigation water are necessary in the growth of crops.

Sometimes it is impracticable to subsoil as much as 18 inches deep, but there is always enough water in the river during the annual floods to give all the bottom lands and vast areas besides all the water they need for complete saturation. The soil should be plowed as deeply as possible, left in a loose, porous condition, and then flooded till this hard stratum is dissolved and capillary action set up between the soil and subsoil. When this condition is obtained, a mulch of 2 or 3 inches will render this action continuous and prevent the re-forming of the hardpan.

WATER SUPPLY FOR IRRIGATION.

The normal amount of precipitation in the Garden City area is not large enough to insure good yields of the crops grown in more humid regions. Therefore, for general agriculture to be a success, it is necessary either to supplement the rainfall by irrigation or to introduce crops that can be grown in a semiarid region. While humid years sometimes occur when large yields are secured, and the rainfall is generally sufficient to produce moderate crops of sorghum, Kafir corn, and alfalfa on the bottom lands and wheat upon the uplands, still with the present methods of cultivation the yields are uncertain and practically total failures sometimes occur. The soils in general are very productive, and irrigation and proper cultivation only are necessary to insure large and profitable returns. It is claimed by practical farmers in the area that one or two good irrigations yearly will give a good steady growth of alfalfa and permit from three to five cuttings annually.

A comparatively large utilization of the soil waters is being made by means of windmills—more particularly with reference to the home garden and lawn. There is, to be sure, a limited acreage of alfalfa and beets irrigated by windmills, but the great cost of providing sufficient power of this character to put large fields under water prevents any considerable extension of this system of irrigation. In the production of all general farm crops advantage should certainly be taken of the flood water of the river. The underground water, of course, comes up clear and adds nothing to the soil in the way of improved texture. Moreover, it soaks rapidly into the sandy soils and where used in small amounts tends to cement the soil particles at from 6 to 12 inches below the surface, thus forming what is locally called hardpan. The use of soil water on gardens and lawns is to be highly recommended in view of the fact that these need water much more frequently than they could possibly receive it from the ditches, but there is no doubt that the flood waters are more beneficial and economical when they can be used.

Several irrigation ditches have been constructed. In 1879 the Garden City Ditch was constructed by the farmers and some of the business men of the town who were interested in irrigation as an experiment. It is now owned by the farmers and has been used more or less ever since its construction. In 1881 what is now the "Farmers' Ditch" was built. It has since been purchased by the farmers, and is now the most serviceable canal in this part of the valley. In 1882 the Great Eastern was dug and has had practically the same history as the Farmers' Ditch. It has only recently been bought by a number of men who are interested in farming and is being put in condition. This canal has excellent farming land under it and should become one of the best, if not the best, canal in the valley. The Amazon was constructed in 1887 by a company at considerable cost and was then bonded for $300,000, thus putting it out of practical use, because in order to secure a fair interest on this sum of money the water rights had to be put so high that the ordinary farmer would not use them. It has since been purchased by the farmers and is now doing good work. While this canal is outside of the area surveyed, if used to its full capacity laterals could be extended into the area and thus afford irrigation to land north of Purcellville. It has a capacity of 400 cubic feet and covers an irrigable area of 8,000 acres.

All of these canals do not appear on the accompanying map, but they all run some distance in Finney County and cover very large tracts of fertile prairie soil. They all have comparatively poor dam sites, and some good work remains to be done along this line. The dams are frequently washed out by the floods, thus throwing the canal out of use for that year.

Many farmers are taking advantage of such opportunity as occurs to flood their fields. However, there are some who are not taking advantage of this means of greatly increasing the yield of their crops. There is enough water in the river and enough ditch capacity in the valley to give every farm from Sherlock to Mansfield from two to three irrigations yearly.

ALKALI IN SOILS.

The area as a whole is free from harmful amounts of alkali. However, the heavier soils of the lowlands contain sufficient salt to become harmful if extensive flooding of the uplands should be practiced. But since economical irrigation does not permit of seepage water, these lowlands should not only remain out of danger from upland irrigation, but what little salt they do contain should be, and can be, eliminated by cultivation. Out of more than a dozen borings and other tests we failed to find in the worst localities a salt content of more than 0.70, and the average quantity was 0.324 per cent. These borings were taken where the indications of alkali were most pronounced and where it is most likely to be found—that is, on the heavy soils of the lowlands along the river and in the depressions on the uplands. The most important alkali district in the area is found in the depression of the White Woman Valley, east of Garden City. On some of the lower levels of this depression there may be seen a white efflorescence of salt during the dry season. Salt grass covers the depression generally, but the percentage of salt is not large enough to interfere seriously with agriculture. Where the soil is thoroughly cultivated the salt grass and other indications of salt disappear. A great deal of this White Woman Valley in this area is used for pasture, and when the salt grass is young it makes a good sweet forage plant. The remainder of the valley is sown to sorghum, macaroni wheat, etc. These both do well and are not injured by the quantity of salt found in the soil there. As stated above, other places in the area have some alkali, but not of sufficient concentration to injure crops in a noticeable degree, except in occasional local spots. The part of the area where the accumulation of alkali is most likely to occur is that part which lies immediately under the low bluff line between Sherlock and the Point of Rocks, on the north side of the river. There is not a serious amount of alkali here yet, but irrigation will have to be carefully and economically practiced in order to keep the salt in the lower and heavier strata of soil where it is at present. There is not very much of this strip, and it can be, and should be, controlled by methods of cultivation which tend to lessen the total amount of evaporation from the surface of the soil. For the management of this strip of heavy soil deep cultivation, flooding with the annual flood waters (not with the underflow water), and subsequent mulching to about 3 inches to prevent evaporation is recommended. Probably the best crops to be grown on this soil are sorghum and sugar beets, both of which tend to rid land of small amounts of alkali.

There is a small amount of alkali in the immediate river bottom in the Laurel loam. The average content is very low, however, and there does not seem to be any reason to expect serious trouble here.

AGRICULTURAL METHODS.

While many of the farmers in the Garden City area have the latest improved machinery and pursue modern methods of agriculture, there are others whose methods of soil management are not suited to the conditions which obtain in this semiarid region. There has been much improvement in agricultural practices within the last few years, but there is still need of further development. Too many farmers are inclined to plant their crops without the proper preparation of the seed bed, and too few use the best methods of handling the soil after the crops have been planted and become large enough to need cultivation.

The moisture supply is one of the most important factors in determining the yield of crops. In an area where the precipitation is not large enough to supply a sufficiency of moisture for the best development of general farm crops and where it is so irregular in distribution and so often in the form of torrential downpours, great care should be taken to make the best possible use of it. The aim of the farmer should be to get as much as possible of the rain water into the soil and then to keep it there until it can be used by the crops. The agricultural methods practiced by a majority of the farmers fall far short of securing these results, and therefore the yields and the profits are not as large as they should be.

The records of the Weather Bureau show that the greater part of the precipitation falls during the months of May, June, July, and August. One of the general characteristics of the rainfall in the region of the Great Plains is that a large part of it falls as heavy showers, and unless the ground is plowed deeply and put in condition so that the rains can readily penetrate the soil the water runs off and the crops do not receive as much benefit as they might. Greater attention should be given by the farmers to the proper preparation of the soil by deep plowing, in order to prevent as much as possible the loss of moisture by the running off of the water. This is especially necessary upon the heavier types of soil, like the Laurel loam, Marshall silt loam, and Colorado adobe. The Laurel sandy loam is more open and porous and admits water more freely, but the moisture conditions of this type can also be improved by this method of treatment.

The good which will result from getting the rains to enter the soil will be largely lost, however, unless the moisture is kept there by maintaining a good surface mulch. The farmers in the area do not generally recognize the importance of this conservation of moisture, and consequently their methods are not adapted as well to it as they should be. The more progressive farmers of the area are beginning to practice what is popularly known as the Campbell system of soil culture. This system is simply and only a practical application of well-known natural laws and agricultural principles.

The farmers following the Campbell system endeavor to achieve two results, namely, first to get the moisture in the ground, and then to keep it there till the plant is ready to use it. This is done in the semiarid West by deep plowing, and even subsoiling, followed by subsurface packing and shallow cultivation and mulching. First make a good, deep, loose-soil reservoir, then when a good rain or snow comes it will tend to fill up the reservoir. As soon as the surface is dry enough disk it, pack it, and mulch it. All subsequent rains can easily and quickly penetrate the soil when it is moist just below the surface. The Campbell system is highly recommended to the farmers in this area.

Until recently few cultivated crops have been grown. Sorghum, corn, and Kafir corn have been raised for some time, but with the exception of corn these were put in with the drill and little or no cultivation followed. The lister has now been introduced and these crops are now usually put in with this implement. The use of the lister is to be recommended for such crops in this area. What cultivated crops are produced, such as sugar beets, potatoes, and vegetables, are grown with the ordinary methods of cultivation.

Some of the farmers take as many as ten or more crops of sorghum from the same field in succession. These farmers would treat other annuals in the same manner, but this practice is to be discouraged. The best farmers in the valley are beginning to see the detrimental effect of such a system and are changing their methods. There is now being introduced a yearly rotation among the annuals, with a noticeably beneficial effect.

Sorghum is now followed by oats, rye, or barley, and beets by sorghum. It is highly probable that the introduction of cowpeas into the rotation would be quite beneficial in adding humus and nitrogen to the soil.

An important question in this area is what rotations and diversification can be introduced in order that the farmers may be mutually helpful when their crops are to be harvested. This question has been partly solved by the recent introduction of the sugar beet and macaroni wheat industries, but these crops do not fully solve the problem.

One difficulty in the solution of the problem is found in the fact that when one man makes a success growing a certain crop, as alfalfa, for example, every other man, without regard to the natural adaptability of his soil to the crop under consideration, begins to seed his fields to alfalfa when he should seed them to wheat or beets or some crop that would not need all of his attention when the hay crop is being harvested. Consequently, when all have some alfalfa growing, some of the hay crop must be neglected and many times lost for lack of help to harvest it.

Farmers in the river valley largely use windmills for irrigating sugar beets, potatoes, strawberries, and garden vegetables. Windmill irrigation is highly recommended for intensive farming, but it is impracticable when applied to general field crops. More extensive irrigation of field crops by means of the annual flood water in the Arkansas River can not be too strongly urged. One or two good floodings in the spring, followed each time by thorough mulching to conserve the moisture, would insure good crops each year, whereas the yields on these farms are always uncertain and in many seasons complete failures. Happily for this part of the country, the importance of irrigation is becoming more and more recognized each year, and better and more certain crops are the result.

Some farmers sow alfalfa on the hard unbroken ground, putting it in less than 2 inches deep sometimes. This practice should be discouraged since many of the seeds fail to germinate and a poor stand results. A good seed bed should always be prepared and this thoroughly saturated some time before the seed is sown. The following method of seeding alfalfa can hardly fail to produce a good stand. Plow the ground deeply in the fall and let it lie loose and open during the winter in order to catch and conserve the winter precipitation. If at any time during the winter this soil reservoir is saturated, or nearly so, the surface should at once have a 3-inch mulch formed over it and maintained until time to sow the seed in the spring. When the soil is once moistened there will be little danger of the subsequent rains running off the surface, but they will sink into the the soil readily, so soon as the thin mulch has been penetrated, and will add greatly to the existing amount of moisture previously stored in the soil. This mulch should be renewed as often as an examination shows the subsurface soil to be getting dry. By keeping the soil moist all winter it will be in prime condition to receive the seed in the spring; the spring rains will penetrate the soil immediately; the soil will show moisture at 3 or 4 feet instead of from 1 to 1½ below the surface, and a good stand of alfalfa can hardly fail to be obtained. The amount of moisture that would be conserved by this method would sustain the young plants for a long time and keep them in a thrifty condition. Then, when the annual floods came down, the field should have the benefit of thorough irrigation. Thus sufficient water would be put into the soil to send the plant roots 10 or 15 feet deep and, in the lowlands, this is sufficient to reach the water table.

AGRICULTURAL CONDITIONS.

General agriculture in the Garden City area is practically confined to the river bottoms. North of Garden City some farming is done upon the uplands, and an occasional field of sorghum or Kafir corn may be seen in some other sections, but the uplands generally are devoted entirely to grazing. A few ranch houses are practically the only dwellings in this part of the area. The uplands are too dry to produce general crops, except in seasons of abnormal rainfall. The introduction of crops better suited to the semiarid region should induce an extension of agriculture upon the uplands.

As practically all of the farmers in the area live upon and cultivate the bottom lands the discussion of agricultural conditions must be practically confined to this part of the area. The majority of the farmers are in a fairly prosperous condition. In humid seasons large crops are secured for which good prices are received. In these years nearly all of the farmers have ready cash. When dry years occur those who do not have their farms under irrigation sometimes find that they have not been able to pay expenses. As the supply of water in the river is rather irregular and uncertain even those who irrigate can not always obtain water at the time when most needed by the crop.

The size of the farms in the valley averages about 160 acres. These farms are nearly all under the ditch, but many of them have no water rights, although rights may be easily obtained should the owners desire to do so. Most of these farms are owned by the men who operate them. There are some large ranches operated by salaried managers, but these are not usually in the river bottom.

The labor question is sometimes quite serious. The farmers complain that when their hay is ready to harvest the wheat crop in that part of the State east of them is also ready for harvest and all the farm hands go away to the wheat fields. It is therefore often very difficult to obtain labor at that critical period. The beet industry is not yet sufficiently well developed to justify the importation of Mexican labor. When this industry has become well established, as it is believed it will in a few years, there should be less difficulty in obtaining labor.

The principal products are alfalfa, sorghum, Kafir corn, spelt, wheat, oats, garden vegetables, fruits, and cattle. Of these the forage crops and cattle are of the most importance. Alfalfa is grown very extensively in the valley. Most of the forage is consumed at years macaroni wheat and sugar beets have been introduced, and promise a bright future for the farmers of the valley. The indications are that macaroni wheat will give the best returns on the Marshall silt loam. The adaptation of soils to other crops is receiving more and more attention each year. It is now recognized that, with equal attention, the greatest tonnage of beets can be secured from the Laurel loam, and this soil also produces the best alfalfa. The uplands have long been recognized as excellent wheat lands, if only enough water could be obtained. Such fruits as cherries, strawberries, and plums do well, but the apple crop is said to be uncertain. A good growth of tree can be had, but the fruit generally fails to mature. It is believed that cantaloupes could be grown with success.

Good transportation facilities are furnished the people of this area by the Atchison, Topeka and Santa Fe Railway. The people are within a few hours of Kansas City, Topeka, St. Joseph, Pueblo, and Denver. These markets can readily handle, and at fair prices, all the strawberries, plums, cherries, peaches, potatoes, etc., that the people of this area have to sell. It costs no more to ship beets from Garden City to Rockyford than it would were the producers living and raising beets within a mile of the factory. This is a great inducement, offered by the factory people to the farmers of the valley.

SOIL SURVEY OF THE CANDO AREA, NORTH DAKOTA.

By ELMER O. FIPPIN and JAMES L. BURGESS.

LOCATION AND BOUNDARIES OF THE AREA.

Towner County is located in the northeastern quarter of the State, and is bounded on the north by the Canadian line. The greatest dimension of the county is from north to south, measuring 48½ miles, or a little more than seven tiers of townships, while its width from east to west is 24 miles, covering four townships. The area surveyed comprises the two southern tiers of townships and has an extent of 288 square miles, being 24 miles east and west by 12 miles north and south.

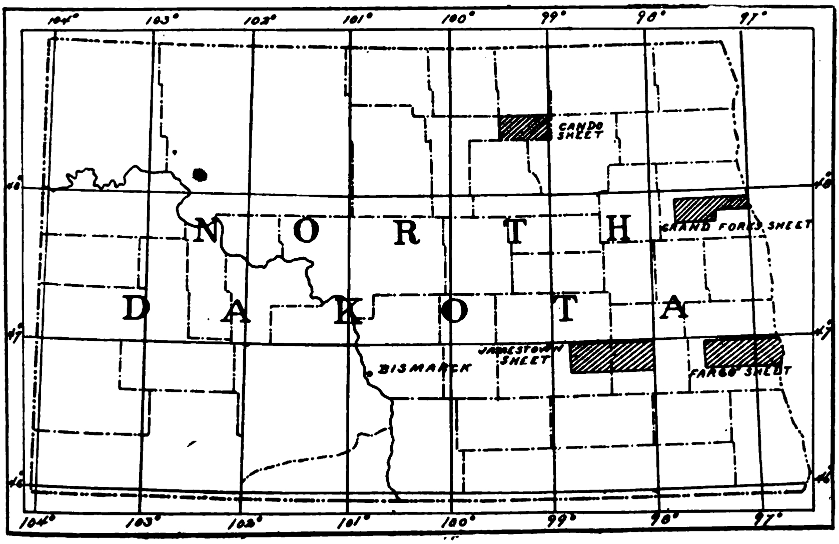

FIG. 39.—Sketch map showing location of the Cando area, North Dakota.

The main line of the Great Northern Railway crosses the State about 8 miles south of the county, and from Churchs Ferry a branch line extends in a northerly direction through the center of the area surveyed to the town of St. John, near the Canadian line, in Rolette County. Cando and Maza are the only shipping points in the area. Cando is a town of approximately 2,000 population, contains a number of substantial business houses engaged in handling the various supplies and products of the region, and is the site of large elevators belonging to six different companies. Maza is a small village, being important chiefly as a grain-shipping center.

In the prosecution of the field work of the survey the Bureau had the cooperation of the State agricultural and economic geological survey, to the extent of furnishing two men and paying their expenses for a period of nearly a month and a half.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The area, like all of the surrounding region, is a comparatively new one agriculturally. It was first opened for settlement in 1883, and under the homestead and other similar Federal enactments, such as the tree-claim and preemption acts, all of the land has been taken up. No land was sold by the Government or granted to transportation companies. Upon the organization of the State in 1889 sections 16 and 36 of each township were given to the State for the purpose of creating a school fund from the moneys derived from the sale of such land, which is disposed of at public auction at a price not less than $10 an acre. Within 8 or 10 miles of Cando and Maza all the land had been taken up under the above provisions at least fifteen years ago, and in the area as a whole no land has been open for homesteading for five or six years. A little more than half the allotted school land remains in the possession of the State, and is the only "public land" available.

During the first six years settlement was rapid and most of the land was filed upon, the title being "proved" to a considerable part; but in the three years beginning with 1888 the crops were almost a complete failure because of weather conditions, and the loss fell so heavily on a large number of settlers that a great many of them were forced to abandon their land, which either reverted to the Government or went to persons holding it as security for loans. Indeed, it is said that at one time following the third failure, in 1890, the exodus was so great that it looked as if the region would be almost depopulated. Under these conditions a few of those who remained and were able to do so acquired much of this abandoned land by purchase at a very low figure. Quarter sections of land sold for $200 and $300, or even less, because, first, there was plenty of land in the vicinity to be acquired by simple residence; and, second, because most of the persons who had lent money on the land were willing, in the face of the financial conditions then prevailing, to accept whatever could be realized from an immediate sale. Large areas of land that now form some of the largest farms were acquired in this manner.

It is said to be a peculiarity of this region that about every third or fourth year since settlement began a large crop has been obtained, while in the intervening years crops have been either only moderate or an actual failure. The year 1891 gave an immense crop, helping those still remaining in the region to retrieve their previous losses, and since that date there has been no repetition of the almost absolute failures of earlier years. In the following prosperous years active settlement was renewed and has continued to this time. Since the early nineties the price of land has been steadily advancing, this being especially true since 1898. Prices now range from $10 up to $35 an acre, depending on the character and condition of the soil and the location of the land with reference to the two towns and the railroad.

The population of the area has been drawn from many States and also from foreign countries. Men from New England and Illinois have settled here, and there are many of Norwegian parentage. Some of the latter, however, are Americans by birth and have come from Wisconsin and Minnesota.

From the very first spring wheat has been the staple money crop, to which all others are subsidiary. Barley, oats, and flax were early introduced to assist in getting the native prairie in good condition for growing wheat, the first two furnishing feed for horses and other stock; but in 1898 the relative prices of wheat and flax were such that on many farms flax was given the preference, and continued to increase in favor until about 1901 or 1902. Since that time the fluctuation in the price of both grains has restored the prestige of wheat, though flax is still grown in considerable quantities as one step in the rotation of crops. Flax and barley have long been considered very satisfactory as the first crop on new land, following which wheat succeeds better than if planted on virgin soil. The flax has always been grown for seed only. Within the past few years macaroni wheat has been introduced into the area and is increasing in favor among the farmers, several hundred acres of it being grown at present. The grain emmer, known here under the name of "spelt," has also been introduced. Both of these grains have been introduced at the instance of the Bureau of Plant Industry.

In considering the agricultural development of the region, the advent of the railroad in 1888 must be regarded as a highly important factor.

The changes in the methods practiced have been chiefly those that accompany the transition from the pioneer condition to the more intelligent system of the progressive, well-to-do farmer, who keeps pace with the improvements along agricultural lines. One change that may be noted in this connection, however, is the different treatment now given to new land, which was at first plowed shallow and the following spring "backset," or replowed after the sod had partially rotted. The land so managed was prepared and planted the same season. Later the "backsetting" was omitted, and a practice now in vogue is to plow and prepare new land in the spring and seed it to a crop like flax. The success of this latter method is more dependent than the other on the moisture conditions of the current year, the yields being larger in wet seasons.

Some inquiry was made to determine whether there had been any appreciable reduction in crop yields on the lands longest in cultivation. The replies were varied, indicating that if there has been any decrease in yield it is so small as to be scarcely noticeable.

CLIMATE.

This area, with an average precipitation of nearly 20 inches, belongs to the semiarid division of the country, but there are certain modifying factors which almost place it in the humid division. An examination of the appended table, compiled from Weather Bureau records, will show that about 75 per cent of the rainfall occurs in the warmer months, from April to October, inclusive. These figures are normals for a series of years, and there are wide fluctuations from year to year, unusually dry seasons alternating with seasons in which the rainfall is sufficient to class the region with the humid country farther east. On the whole, the problem of a sufficient moisture supply is the most important one in the region, and the one that most largely determines the crop returns under the methods practiced. In the season of 1904, however, an excess, and not a deficiency, of rain caused much injury.

Frosts always occur early in September, and between the 1st and the 15th of November permanent low temperatures begin to prevail, the ground freezing and remaining so until the following spring. The humidity in winter is low, and consequently the low temperatures are not so severe on animal life as the figures would seem to indicate. Snow generally covers the ground to a depth of several feet throughout the winter, but the total amount of water that falls in this form, as shown by the tables, is only a fraction of an inch during each of the coldest four months. The ground freezes to a depth of from 5 to 8 feet.

About the 1st of April the soil begins to thaw, and usually from the 10th to the 20th of the month plowing and cultivation are possible, even though the soil be frozen below. By the 1st of May, or even earlier in some years, the surface soil is warm enough to germinate seed.

In this region a given amount of water is more effective in causing crop growth than in warmer sections, because the surface evaporation is less. As is indicated by the temperature of the ground water near the surface in wells and other places, the lower subsoil never becomes very warm. All processes of oxidation and decomposition are correspondingly slow, and this fact, coupled with the additional one that the seasons are comparatively short, probably explains why all the soils are so rich in humus or partly decomposed organic remains. There is a comparatively small amount of leaching.

In winter the temperature sometimes falls to 40° below zero, and the general conditions are very severe on animal life. In summer hailstorms sometimes do great damage to crops if they happen to be in a nearly ripe condition. These storms, however, are never of general occurrence, and usually cover narrow strips from a fraction of a mile to several miles in width.

There is a free and unobstructed movement of the winds, which occasionally attain high velocities, but the damage to crops from this cause is not great, as in some parts of the West.

Normal monthly and annual temperature and precipitation.

Month.	Churchs Ferry.		Dunseith.		Month.	Churchs Ferry.		Dunseith.	
	Temperature.	Precipitation.	Temperature.	Precipitation.		Temperature.	Precipitation.	Temperature.	Precipitation.
	°F.	*Inches.*	*°F.*	*Inches.*		*°F.*	*Inches.*	*°F.*	*Inches.*
January	2	0.63	5	0.10	August	65	1.84	64	1.85
February	3	.51	1	.30	September	55	1.40	....	....
March	16	.96	14	.65	October	41	1.71	....	....
April	40	2.38	40	1.00	November	17	.87	25	.40
May	53	2.02	54	.90	December	9	.50	8	.10
June	63	3.98	64	3.58	Year	36	19.20	....	....
July	68	2.40	68	2.51					

PHYSIOGRAPHY AND GEOLOGY.

In surface features the Cando area is an undulating, treeless prairie, a little rougher near the borders than in the central—particularly the east-central—part. The area is also slightly trough-shaped, with the lowest portion forming a broad, shallow valley that crosses the survey a few miles east of the center. The elevation varies from about 1,475 feet to nearly 1,600 feet, and the general slope is southward. The topography consists of low elevations, the great majority of which have a general northerly and southerly trend. All of the elevations have gentle, gracefully rounded slopes. The topography, however, is not of the dissected type, and bears scarcely any relation to stream-erosion forms, but has been produced by entirely different factors, to be discussed a little further on. Three miles north of Cando, and in a few other places, the surface is made up of knolls and kettlelike depressions, some of which contain small lakes.

The drainage system of the region is unique in several respects. The rather extensive system of streams and drainage lines has not been developed by the present rainfall, and consequently they are not actively eroding their channels. Many of the streams, or coulées, as they are called in this section of the country, are quite large, and their meandering course indicates that at the time they were developed the fall was not great and the water moved rather slowly. The main stream is the Big Coulée, which crosses the area a few miles east of Cando. With the exception of a small extent of country in the extreme southwestern part, the drainage of which flows into the Hurricane Lake system, the drainage water of the area finds its way into the Big Coulée, either in the county or at some distance to the southward. All of the channels are much clogged by a growth of water-loving plants. At intervals many of the streams pass through broad swales or swampy depressions, from an acre or two to many acres in area, over which the water spreads, while throughout the extent of the survey are numerous shallow depressions of about the same size with no outlets that contain from a few inches to a foot or two of water during most of the year. In the eastern half of the area, aside from the southeastern corner, many of these swamps have the appearance of having been part of a main line of drainage, and are traversed by a distinct channel. In addition, along all of the coulées are many abandoned channels of ox-bow form that have been sufficiently filled to make cultivation possible. The most notable examples of this occur along the Big Coulée northeast of Cando. The former meandering of this stream over a wide territory is here very evident.

In the course of the survey it seemed advisable to indicate on the map numerous lines along which the drainage water collects, and along which, at some earlier time, it was probably drained, and this has been done by means of broken lines. At present these are indicated by poorly drained areas of soil, with discontinuous wet-weather swamps, too small to be shown in the usual way, yet having considerable influence on the agricultural value of the land they traverse.

A further peculiarity is the way in which the various coulées are connected by these lines of drainage, and also the parallel position and near approach of several of the systems to each other. A study of the accompanying map will show two large coulées coming down from the north, one on each side of the Big Coulée, which they gradually approach and into which they finally empty. These, in turn, are formed by the union of streams, which continue parallel and near to each other for distances of several miles.

The surface geology of the area and of all the surrounding country is of the glacial type. The Dakota lobe of the ice pushed down over this country, forming a continuous mantle of glacial till, and during its recession and temporary advances formed lines of gravelly hills called terminal moraines. Associated with these is the roughest topography of the area, in which are found the small glacial lakes.

The melting of the ice during the period of recession produced large volumes of water that drained off to the south, and it was this water, derived from the glacier in the immediate vicinity and from regions many miles to the north, beyond the Turtle Mountains, that produced the system of coulées mentioned above. In The Story of the Prairies, Professor Willard describes the Big Coulée as forming an outlet from large bodies of glacial water far to the northward into Devils Lake and thence into the Red River Valley. The passage of this large volume of water through the area, as floods laden with sediment, and with varying currents, is responsible for the deposit of the large masses of material giving rise to the soils of the area, other than those formed directly from the bowlder clay. The various grades of sand and gravel, mostly stratified in the form of bars and ridges, and of the large mass of silty clay in the vicinity of Cando, were probably formed by this agency of the glacial waters. All of the surface forms are the result, directly or indirectly, of the action of ice, and the depth of the glacial material ranges in different parts of the area from 30 or 40 feet to more than 100 feet.

SOILS.

The most prominent characteristic of the soils in this area is the large amounts of organic matter and lime they contain, as compared with soils of similar texture farther east and south.

The preponderance of organic matter is not due to a larger original amount produced in the soil, but, as was intimated in the discussion of climate, it is a result of the meteorological conditions. The source of all the humus is the plant roots and stems that were left in the soil from season to season by the prairie grass before cultivation began and by the cultivated crops now. All processes of decomposition are hastened by a high temperature, and the longer it continues the more thorough they will be. In this region the summers are comparatively short, the atmospheric temperature is not high on the average, and the soil temperature is comparatively low. This condition hinders the bacterial and fungus growths that are essential to rapid decomposition of organic matter, and a gradual accumulation of humus is the result.

The amount of humus present is the cause of the dark color of the soils of the area—a color that tends to increase the amount of heat absorbed during sunshine, thus maintaining a higher soil temperature. This is an important factor when associated with areas having as short growing seasons as here, and it is probable that the crop adaptation of the region would be quite different if the soils were a very light color, even though they contained the same amount of plant food as at present.

A large amount of lime is distributed through but is most abundant in the loams and gravelly loams. It has been derived from the grinding up by the glacier of lime-bearing crystalline rocks and also of considerable amounts of limestone. This has been subsequently redistributed and in some places concentrated through the agency of the soil water. The largest accumulations are between the twelfth and the thirtieth inches, where lime sometimes appears to form more than a third of the bulk of the soil. In gravel beds covered to a depth of from 15 to 30 inches by silty material all of the pebbles in the upper part of the gravel are covered with lime, or the whole mass may be cemented together by depositions from the water leached from the soil above.

This large amount of lime is very useful in the soil, since it tends to increase the granulation of the fine-textured types, prevents acidity from the decomposition of the organic matter, which process it hastens, and is favorable to the growth of the grains most abundantly produced in the region. For the growth of flax, however, less lime is desirable.

Five types of soil have been recognized, the names and extent of which follow:

Areas of different soils.

Soil.	Acres.	Per cent.
Marshall loam	79,936	44.2
Clyde loam	70,016	38.7
Clyde clay	18,880	10.4
Clyde fine sandy loam	10,880	6.0
Marshall gravel	1,344	.7
Total	181,056	

All of the types appear very silty in the field, and, except on the lightest sand and gravel points, which are very small in extent, there is considerable similarity in the first 10 inches of soil throughout the area.

CLYDE LOAM.

The soil of the Clyde loam is a black silt loam or loam, with an average depth of 12 inches, but with a range of from 10 to 24 inches. The greater depth is found in the lowest positions adjacent to the coulées. The subsoil is a light-colored silty clay loam, or clay, the upper part, when dry, being a pale yellow to gray, and the color changing to a darker yellow with increased depth. The type has little material coarser than the finer grades of sand.

The Clyde loam is distributed throughout the area, but the largest body is in the eastern half, where it is the predominating type, and occupies a sort of broad, flat basin, about 10 miles in width, cut at intervals by areas of other types. Toward the eastern boundary of the area and throughout the western half it is the type of second importance in extent, in the latter location forming elongated bodies of variable size surrounded by the Marshall loam.

The surface in general is nearly level or only slightly undulating, while in detail it is appreciably uneven in a number of places, due to shallow channels and saucer-shaped depressions. The large area first mentioned lies at an elevation halfway between the highest knolls and the lowest depression, and in other parts it fills many of the troughs in the surface of the Marshall loam. The shallow depressions mentioned are rather numerous throughout the type, but most of them are of very small extent—less than 2 acres. Where they are of considerable size they have been mapped as a distinct type, because the drainage conditions are such that the soil has been much modified.

The natural drainage of the type is not perfect, and in a region of greater rainfall the condition would be serious; but with the usually light precipitation of this section little trouble is experienced from excess of water, and then only in the wettest seasons and over a comparatively small proportion of the type. Most of the coulées are bordered by the Clyde loam, and it surrounds most of the swampy areas mapped as Clyde clay. Near these in wet seasons the crops may be damaged. In addition, there are lines along which, when there is an excess of moisture, the water tends to accumulate, forming a series of wet-weather ponds a few rods in extent. The most prominent of these lines of drainage have been indicated on the map by broken blue lines. In average seasons all such places may be readily cultivated, and give the largest yields, although there is loss of crops in a wet season. Much of such land could be drained by constructing open or tile drains emptying into the adjacent coulées. Remote from outlets, however, it would not be practicable to put in a drainage system for small areas that are injured only about every fourth season.

Some minor variations from the typical soil material, and other peculiarities in texture that are best described at this point, are: The more coarse and mealy character of the soil in the immediate vicinity north and east of Cando; the noticeably fine sand content of the soil for some distance out from the borders of the bodies of the Clyde fine sandy loam, especially north and east of Cando; the heavier and somewhat clayey subsoil in the lowest places where the drainage is defective, and the slightly heavier character of the type, as compared with the large eastern area, in the small bodies surrounded by the Marshall loam.

The origin of the Clyde loam is not well understood, but it is thought to be the result of the accumulation of material in the lower levels by the drainage water. Since the volume of this drainage is insignificant at present, the material must have been deposited at some earlier time, presumably during the period when the drainage of the retreating glacier passed through the area. In the vicinity of Cando the depth of this material is 10 feet or more. The character of the surface and the relation of the material to the coulées, as well as to the numerous abandoned channels, which are very prominent along the Big Coulée, northeast of Cando, would seem to indicate the deposition of the material by shallow, slow-moving flood waters. There is no important variation between the material forming the type on the highest levels and that on the coulée bank. The soil is usually a little deeper next to the coulée, but the subsoil is of the same light-colored, clayey character. An example of this occurs along the coulée northeast of Maza, through several sections, and includes several hundred acres, where the black soil is several feet deep next to the channel, and gradually shallows toward the highest level.

The type may be regarded as a secondary material derived originally from the glacial till, but that it is distinct from the bowlder clay is evident.

A large quantity of lime is distributed throughout this soil and is often apparent from the color of the material. The accumulation is largest in the upper part of the subsoil. There is also present a large amount of gypsum ($CaSO_4$), mostly in a crystalline form. It occurs as a granular material in small pockets and seams through the section of the subsoil.

In general, the alkali salts are not sufficiently abundant to be injurious to crops, but there is a slight excess in some instances that is more fully treated under "alkali soils." It is found in the lowest places, where the drainage is most defective, and is most concentrated in the lower part of the soil section.

All the crops of the region, including wheat, barley, oats, flax, and potatoes, are grown on the Clyde loam with good results. In its natural condition it has the highest productive power of any of the soils. In the best seasons wheat will yield from 30 to 35 bushels, barley 40 to 50 bushels, oats 45 to 60 bushels, and flax from 18 to 23 bushels per acre. Not enough corn is grown to determine what the yield would be. Potatoes make 200 bushels or more. These yields represent the maximum returns in favorable seasons, and are the only true guide to the productive power of the soil. In other seasons a great variety of yields is obtained, depending on the amount of rainfall and the management of the land. It is in fact the best soil in the area for the staple crops of the region, and is also well adapted to the production of potatoes. The same soil farther south would be an ideal one for corn growing. In this latitude, however, a lighter type of soil is better suited to corn. A variety of forage crops and grasses suited to the climate may also be grown successfully. The smooth brome grass thrives on this type. In the best-drained positions potatoes may be made to yield very well, the tubers being of the finest kind. A variety of garden vegetables is also grown, and some excellent small fruits, such as currants and gooseberries, are produced.

In its relation to moisture the type is very satisfactory. It is readily cultivated into a friable loam that takes up water quickly and conducts it into the subsoil, which has a large water-holding capacity. With proper cultivation to conserve moisture, the most protracted droughts of the region may be withstood and fair crops obtained.

The following table gives mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Clyde loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11646	SE. ¼ sec. 17, Maza Tp.	Black loam, 0 to 12 inches.	1.0	4.9	3.9	15.7	15.8	42.4	16.2
11644	Cen. sec. 26, E. half Badger Tp.	Black silty loam, 0 to 12 inches.	.5	1.1	1.5	9.9	11.2	55.7	19.5
11648	SE. ¼ sec. 20, W. half Badger Tp.	Dark loam, 0 to 12 inches.	.8	2.6	3.0	8.8	11.0	48.9	24.6
11649	Subsoil of 11648	Clay loam, 12 to 36 inches.	1.6	5.3	4.1	10.1	9.8	34.8	34.1
11645	Subsoil of 11644	Clay, 12 to 36 inches	.0	.3	.5	5.2	4.8	47.6	41.5
11647	Subsoil of 11646	Clay, 12 to 36 inches	1.4	3.3	2.1	4.3	5.7	38.2	45.0

The following samples contain more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 11645, 17.8 per cent; No. 11646, 3.2 per cent; No. 11647, 17.4 per cent; No. 11649, 13.8 per cent.

MARSHALL LOAM.

The soil of the Marshall loam is a loam or heavy sandy loam of very dark or black color, containing a small percentage of fine gravel. It is not a very uniform soil, and there are many small, low knolls, from a few feet to several rods in extent, where the material is very gravelly, while in intervening areas the texture is more silty. At from 1 to 2 feet below the surface there generally, but not always, occurs a thin stratum a few inches thick consisting largely of coarse sand and gravel, while from 12 to 20 inches the material is of a light, often gray color, which is due chiefly to the presence of a large amount of lime carbonate, in extreme instances forming from a third to a half of the bulk of the soil.

The subsoil below the gravelly stratum is a stiff, gritty material, sticky and pasty when wet. The color is a light gray, which changes to a yellow with increased depth. The angular fragments of sand and fine gravel may make up a considerable part of the mass and are mixed uniformly through it. When this gritty material becomes dry it bakes and becomes very hard and resistant.

The Marshall loam is the predominating type of soil in the western as the Clyde loam is in the eastern half of the area. Its surface is very gently rolling or undulating, but not to an extent to interfere with cultivation. The surface is made up of low, rounded knolls and ridges, a large majority of which have a northerly and southerly trend. On some of the higher points are found small beds of gravel that would be classed with the Marshall gravel if they were of sufficient extent. In sections 7 and 18 of Maza Township, on top of a high ridge at that point, these gravel and sand pockets are rather numerous, and associated with them are many large bowlders. These bowlders range from a few inches to several feet in diameter, and bowlders of the same general character are of common occurrence throughout the type. They are angular and subangular in shape, and composed of a variety of minerals. Various kinds of granites are common.

Kettle holes are of frequent occurrence. Many of the depressions between the ridges and knolls are poorly drained and often swampy. This gives rise to the many areas of the Clyde clay associated with this type, which will be noticed on the map, particularly on the eastern margin and in the west-central part. Their presence is a considerable hindrance to cultivation in some places, because they cut the surface into irregular areas.

With the exception of the lowest parts of the depressions between the ridges the drainage is good, and even in the areas excepted, if they are of considerable extent they are shown as a different type. The Marshall loam, as a rule, forms the most elevated part of the area and has a moderately sloping surface and the excess of water readily drains away, while the soil itself being of a porous character, the water that falls upon it is rapidly absorbed. The subsoil, however, is more dense and impervious and absorbs water slowly. The 20 inches or more of porous material on the top has a decided power to retain moisture, and keeping it in contact with the subsoil for long periods the latter gradually becomes moistened. Thus a large amount of moisture may be stored and, by proper cultivation, retained until cheaply drained, while for others the process would be too expensive to be practicable under present conditions.

The Marshall loam is formed by the weathering of the true bowlder clay which comes to the surface in the areas indicated by the occurrence of the type. With this weathered material have been incorporated considerable quantities of organic matter, but at a considerable depth the blue bowlder clay is found in its original condition, the difference in color being due, it is believed, to the change in form of the compounds of iron, due to weathering.

This type contains more lime than any of the others, but a comparatively small amount of gypsum, and that in the most silty areas. The lime is most concentrated between the twelfth and the twenty-fourth inches, where it may constitute the greater part of the soil mass. The included pebbles are usually heavily coated with it. The small depressions mentioned are often encircled above the line of saturation by a band several feet in width, in which there is a large accumulation of lime at the surface. On these places flax is invariably a failure, and other crops may be affected.

All of the staple crops of the region are produced on this type, but are less uniform in growth than on the Clyde loam. The crops are best in the wet seasons, but even then a slightly spotted appearance in the fields may be observed. In a dry season this lack of uniform growth is much more noticeable. The coarse stratum, being unequally distributed, checks the proper movement of moisture upward to the plant roots, especially when the upper part of the section has become very dry. The process of movement from one part to the other is very slow, and if the upper soil be quickly dried out the plant will suffer for moisture before the supply is replenished from the lower subsoil. There is, in addition, probably a hindrance to the downward development of the plant roots. With the best management the yields of the grain crops may be made to approach very near to those given for the Clyde loam. Flax, however, does not do quite so well.

The following table gives the mechanical analyses of typical samples of the soil and subsoil of the Marshall loam:

Mechanical analyses of Marshall loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11642	SW. ¼ sec. 16, W. half Badger Tp.	Gravelly loam, 0 to 12 inches.	1.2	4.9	3.2	13.8	18.0	42.4	16.6
11638	NW. ¼ sec. 7, Athens Tp.	Gravelly sandy loam, 0 to 20 inches.	7.6	17.9	15.5	15.6	4.6	16.1	22.5
11640	NW. ¼ sec. 17, Coolin Tp.	Black loam, 0 to 18 inches.	3.0	4.7	5.7	18.7	17.4	24.1	25.9
11639	Subsoil of 11638	Sandy clay, 20 to 36 inches	9.2	23.4	15.3	15.0	3.8	11.2	21.8
11641	Subsoil of 11640	Sandy-clay loam, 18 to 36 inches.	2.0	6,2	3.7	13.9	17.0	25.2	31.2
11643	Subsoil of 11642	Light-colored clay, 12 to 36 inches.	2.2	5.2	3.4	10.8	10.0	28.6	39.8

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 11638, 11.3 per cent; No. 11639, 20 per cent; No. 11640, 8 per cent; No. 11641, 25.3 per cent; No. 11643, 17.3 per cent.

CLYDE FINE SANDY LOAM.

The Clyde fine sandy loam consists of a very dark or black fine sandy loam, 12 inches in depth, beneath which is a pale-yellow or gray fine sandy loam or fine sand that extends to a depth of from 2½ to many feet. The sand subsoil is found in areas occurring on the highest knolls. This is the case on the highest elevations in section 1 and the northeast quarter of section 8 in the eastern half of Badger Township; and through the center of section 19, in Maza Township, the subsoil is in part a very clean sand, near the medium in grade.

This type is confined almost entirely to the eastern half of the area, where it forms several bodies of more than a square mile in extent. It is closely associated with the Clyde loam and Marshall gravel, and occurs most commonly in small bodies surrounded by the former type and around the base of the latter as a gradation type.

The surface of all of the small bodies of the type is in the form of low knolls or ridges with a gently rounded outline. In sections 4, 5, and 6 of Coolin, and section 1 of Maza Township it occupies the intervening depressions as well as the elevations. In the comparatively large areas north and east of Cando it forms hills of considerable height.

Owing to the elevation, the slope of the surface, and the porous character of the material, the drainage is exceptionally good.

The origin of this type, like that of the Clyde loam, is believed to be associated with the post-Glacial drainage of the region. It is frequently underlain by silt, and often occupies such a position with reference to the drainage channels as to suggest its having been deposited in part by the flood waters of an earlier time. It is free from pebbles and Glacial bowlders. It is rich enough in lime to effervesce freely with acid, although the soil particles do not appear to be flocculated to any great extent. No crystals of gypsum were observed in this soil.

All of the staple crops are grown, but the yields are appreciably less than on the Clyde loam, and, as a rule, are less than on the Marshall loam. In some instances, where the sand formation is not over 3 feet in depth and grades into silt, the crops are as good in a moist year as on either of the other types. But the moisture-holding power as a general thing is less and the soil is more affected by dry weather. On the average, wheat will yield from 20 to 25 bushels in the most favorable seasons, and other crops proportionately. Some uniformly good crops of flax were observed on this type, but the yield of seed is not so large as on some of the types already described. For the production of corn, potatoes, and garden vegetables it is the best type in the area, because it is a warmer soil, but it can never be made to produce yields of the small grains equal to those of the heavier types. One essential condition to the production of corn and the other crops enumerated is frequent cultivation to conserve moisture.

The following table gives mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Clyde fine sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11636	NE. ¼ sec. 6, Coolin Tp.	Fine sandy loam, 0 to 15 inches.	0.3	1.4	4.8	36.4	28.1	18.8	10.5
11634	Cen. S. line sec. 2, E. half Badger Tp.	Fine sandy loam, 0 to 12 inches.	.2	2.9	5.6	34.2	25.6	19.8	11.5
11637	Subsoil of 11636	Fine sandy loam, 15 to 36 inches.	.2	1.0	3.2	35.5	35.7	10.0	14.4
11635	Subsoil of 11634	Fine sandy loam, 12 to 36 inches.	.6	4.7	7.7	34.8	22.9	12.8	16.0

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 11635, 9.4 per cent; No. 11637, 5.3 per cent.

MARSHALL GRAVEL.

The soil of the Marshall gravel is a dark-brown or black sandy loam, 8 or 10 inches in depth, and containing a considerable proportion of coarse sand and fine gravel. The subsoil consists of loose coarse sand and gravel, much cross-bedded and several feet in depth.

The type is of small extent, occupying not more than 2 square miles. It forms narrow, elevated bodies at widely separated points. Two of these are in the southeastern and southwestern quarters of the area, respectively, and a third and the largest is on the northern margin north of Cando.

The Marshall gravel occurs as isolated knolls and ridges, and is found capping the highest elevations in the area. The largest area forms a large hill, the general surface of which is rolling.

The origin of the type is in some way associated with the glacial drainage of the region. The gravel is very angular, and some of the strata consist of nearly pure quartz sand, while others are made up largely of shale fragments, including an occasional large bowlder. In the upper part of the beds, immediately beneath the sandy soil, the rock fragments are heavily coated with lime.

The surface soil is too shallow and the soil as a whole too droughty for successful crop production, and although most of it is in cultivation to the small grains, the yields are small, in dry seasons scarcely any grain being obtained.

CLYDE CLAY.

The Clyde clay, from 8 inches to 2 or 3 feet in depth, is a black clayey loam, very rich in organic matter, with surface accumulations of a few inches of muck in some places. Beneath the dark soil is a very light-colored, often nearly white, material that varies from a heavy pasty clay to a heavy silty clay, in some instances mixed with sand and gravel, although the last is of infrequent occurrence. The subsoil usually found is a rather heavy clay that becomes more silty at a depth of 3 or 4 feet. In some instances the clay is underlain with sand. Where the heavy clay approaches to within 3 or 4 inches of the surface, so that it interferes with cultivation, it is called "gumbo."

The Clyde clay is scattered through the area in bodies from a few rods up to several hundred acres in extent. It is associated with all of the other types and occupies the lowest levels. It occurs along coulées, in abandoned stream courses, in depressions at higher elevations, and in all other places where the natural drainage is very defective.

The type owes its origin to its low, flat surface, which is often dish-shaped, and the consequent poor drainage. It represents areas where the surface water accumulates and where the small amount of fine material carried in suspension has been deposited from year to year to form the fine clay. In this material, which is covered by water to a depth of several inches during much of an average season, many water-loving plants—mostly grasses—grow in great luxuriance, their decaying roots and stems accumulating from year to year and with the annual addition of sediment forming the rich black clay loam that covers the bottom of such places.

Most of the type is a virtual swamp during the early part of the season, and in wet years is covered with water through the whole summer. On the map this part of the type is designated by swamp symbols. Other parts that have been formed in the same way, but over which better drainage has been established, are under cultivation. The largest of these are in the center of Maza Township, and adjoining the Big Coulée in the southwest corner of Coolin Township. The soil of these areas is a heavy black clay, to which the name " gumbo " is frequently applied. A large part of this type may be cheaply drained, but there remain other considerable bodies over which it would be very difficult and expensive to establish drainage, because of the lack of a ready outlet.

Most of the alkali in the area is found in this type. The salts are apparently accumulated in these places through the agency of the drainage waters, and subsequently concentrated by evaporation, which in some seasons is relatively great. Heavy crusts of salt often form on the borders of the saturated soil, and over small areas all vegetation is killed. The water in such depressions is often brackish, and in some places more so than in others. The problem of drainage and cultivation for the correction of alkali soil is discussed under " alkali soils."

Those areas of the Clyde clay with a fair drainage are devoted to the production of grain, and in seasons of moderate rainfall very large yields are obtained. In very wet seasons, like the present one (1904), the crops over a great part of the area are ruined by the excess of water. If properly drained and well cultivated this type will produce larger yields of wheat than any of the other types in the area. Most of the type is at present used for the production of natural grasses, which in the average season furnish nearly all the hay used in the area. If the areas do not become dry the hay can not be cut, as was the case in the season of 1904, but even in this case a large quantity of hay is obtained around the edges of the areas, where in other seasons scarcely anything would be harvested. The fact that so much and so good hay is obtained from these wet places inclines the farmer to retain them in their present condition rather than to put them under cultivation, especially as this would generally entail considerable expense for drainage.

The following table gives mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Clyde clay.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11652	SW. ¼ sec. 23, E. half Badger Tp.	Loam to clay, 0 to 12 inches.	0.0	0.7	0.8	6.3	14.7	43.7	33.7
11654	SE. ¼ sec. 20, W. half Badger Tp.	Black clay loam, 0 to 20 inches.	Tr.	1.4	1.4	6.8	7.1	45.6	37.7
11650	SE. ¼ sec. 16, Maza Tp.	Black clay, 0 to 12 inches.	.4	1.0	1.0	5.3	5.6	42.4	44.3
11653	Subsoil of 11652	Clay and silty clay, 12 to 36 inches.	.0	.2	.3	5.9	24.4	32.2	36.9
11655	Subsoil of 11654	Heavy clay, 20 to 36 inches.	Tr.	.8	1.0	4.0	6.8	48.3	39.1
11651	Subsoil of 11650	Dark stiff clay, 12 to 36 inches.	.0	.8	.8	3.2	4.1	32.0	59.1

The following samples contain more than one-half of 1 per cent calcium carbonate ($CaCO_3$): No. 11651, 7.4 per cent; No. 11652, 1.1 per cent; No. 11653, 3.4 per cent; No. 11654, 1.9 per cent; No. 11655, 1.9 per cent.

ALKALI SOILS.

Except in a few instances, the condition of the soils of the area as regards excess of injurious salts is not serious, and under proper methods of soil management will never affect seriously the productiveness of the soils in this part of the State.

While there is a considerable quantity of alkali through the glacial mantle, and while in a truly arid climate and with careless irrigation the conditions are such as would give cause for alarm, the rainfall is sufficient to prevent any marked accumulation of the salts within the root zone of the soil over by far the greater part of the area, and what accumulation has taken place is confined mainly to localized spots in small depressions, or in somewhat larger areas of poor drainage. The salts found in such places have been leached from the soil of higher lying areas by the rain water, and have been retained there through obstructed drainage.

A few places were observed on the uplands in the vicinity of some of the larger moraines where the alkali was gradually being leached out of the glacial material and brought to the surface lower down, on the gentler portion of the slope, but the most important occurrences of the alkali salts are confined to the poorly drained areas along the sloughs and coulées and in the vicinity of the lakelets. Among the more important occurrences may be mentioned the lowlands along and northwest of Maza, a tract around Hurricane Lake, and a small area about 4½ miles north of Cando. Other small areas are found in various parts of the eastern half of the survey. As already stated, the alkali in this area nearly always occurs in small spots and patches, which usually mark places of obstructed drainage.

The alkali in this area owes its origin to the grinding down by glacial action of the various silicate rocks that lay in the path of the ice sheet. Innumerable rock fragments are found scattered all over the country, and range in size from small pebbles to bowlders weighing many tons. Rocks containing the lime, soda, and potash feldspars predominate, while scattered here and there are found many of the more basic igneous rocks, such as diorites, diabases, gabbros, and various members of the peridotite group. It is doubtless true that from the comminution of these basic igneous extensions much of the sulphur, relatively so abundant in the soil in the form of sulphates, is derived.

Most of the salts in the Cando area are in the form of sulphates. Samples from the worst alkali spots when analyzed by the Bureau of Soils showed that no sodium carbonate was found; neither was any detected by titrations made in the field. The sulphates of calcium, potassium, sodium, magnesium, and the bicarbonates of the last three constitute the principal salts. Some sodium chloride, or common salt, is present, but none of the analyses showed as much as 2½ per cent of the total salt to be sodium chloride, while there was often 85 per cent of the sulphates. Most of these salts are soluble in water, the principal exception being that of calcium sulphate, or gypsum, which is relatively insoluble.

While the soluble salts of this area are distributed throughout the whole mass of the soil, it is interesting to note the total absence of harmful amounts of alkali in the surface of nearly all the well-drained upland soils. This is especially true in the case of the Marshall loam. The Clyde loam usually contains more salt than any other type in the area, except the clay loam along the coulées and sloughs. In all the well-drained areas, where the alkali is at all noticeable the amount always increases with depth. Cultivation, cropping, and surface leaching have removed the excess from the surface few inches. Excessive accumulation has been largely kept in check by the nature of the crops grown—crops that tend to allow the least possible amount of evaporation during the growing season; by the large amount of humus in the soil, which creates humic acids that tend to neutralize the alkalinity of the soil; by summer fallowing, which inverts the soil and places next to the subsoil any excess of salts that may have accumulated on the surface, and by the spasmodic nature of the rainfall, which occasionally comes as cloudbursts and flushes from the surface the alkalies that have been deposited by evaporation.

Near the coulées and sloughs and in all the poorly drained areas in the survey the distribution of the alkali in the soil is different from its distribution on the higher levels. Here evaporation causes the salts to accumulate on the surface, and many places are seen in these lowlands where plants are either dead or dying.

The accompanying table shows the amount of salt to increase with depth. Borings Nos. 13, 15, and 20 were taken in poorly drained areas where evaporation had deposited considerable salt near the surface.

Table showing distribution of salts in soil as found in Cando area, North Dakota.

No. of boring.	Location.	Foot.					
		First.	Second.	Third.	Fourth.	Fifth.	Sixth.
1	SE. ¼ sec. 36, R. 65 W., Badger Tp	0.05	0.32	0.46	0.495		
5	NW. ¼ sec. 5, R. 65 W., Coolin Tp	.225	.145	.115	.055	0.068	0.068
6	Same as No. 5, but a few feet away	.042	.05				
7	Same as No. 5, but a few rods away	.04	.05	.08			
11	Sec. 16, Maza Tp	.51	.64	.69			
12	NE. ¼ sec. 31, R. 65 W., Badger Tp	.16	.33	.41			
13	NE. ¼ sec. 6, Maza Tp., near coulée	.54	.24	.20			
15	Big salt flat NW. of Maza	.94	.74	.80			
20	SE. ¼ sec. 32, Maza Tp	.47	.24	.23			
22	NW. ¼ sec. 12, R. 65 W., Coolin Tp	Tr.	.44	.44			
24	SW. ¼ sec. 31, R. 65 W., Coolin Tp	.19	.41	.60			

In the more important alkali areas along the sloughs and coulées surface drainage should be resorted to wherever possible. Underdrainage is usually impracticable, and in most cases unnecessary, because the only requisite is that the salts be kept below the zone of root action, and good surface drainage, with deep and thorough cultivation, accomplishes this result, the crops of the area being for the most part shallow rooted.

AGRICULTURAL METHODS.

The region is devoted almost exclusively to grain production, and of the grains spring wheat is far in the lead in acreage and total yield. It is the staple money crop. The other crops grown are barley, oats, flax, emmer (spelt), hay, and a very little corn, and some millet. The wheat, flax, and part of the barley are marketed, and the remainder of the grains and the hay are fed on the farm. The hay is almost all derived from the swampy places mapped as the Clyde clay. A little smooth brome grass is grown, but its introduction was recent, and it is confined to a number of small areas that are chiefly experimental. It appears to be adapted to the soil and climate, and, as it is both a good hay and pasture grass, the acreage will undoubtedly be greatly increased. It does best on the Clyde loam, and fairly well on the Marshall loam.

For wheat, and in fact any of the grains, as much of the land as possible is plowed immediately after harvest, as owing to the short season there is none too much time in the spring. The depth is from 5 to 7 inches, except in breaking the prairie sod, when only 2 or 3 inches of the soil is turned. The fall-plowed land is generally left in the rough condition through the winter, but a few farmers harrow down their land as fast as plowed, and repeat the process as often as time will permit. They claim profitable results from the practice. In the spring the plowed land is worked into condition, and as early as the season will permit—in the latter part of April or in May—the seed is sown. The thoroughness with which the seedbed is prepared varies greatly with different farmers and in different seasons, but it is generally known that the more care and time bestowed in this preliminary work the better the crop returns will be, especially if the season be an unfavorable one. Wheat is seeded first, and the other crops in the order of their importance to the particular farmer. Oats, emmer, and flax require a comparatively long season, while barley will mature much more quickly. As a consequence, a greater acreage of barley is sown in wet years, when the season has become late for sowing the other grains. It is often sown in sloughs and wet, cold places in the other grain fields, where it alone will be able to mature.

No well-established rotation is practiced, though many farmers have a succession that they prefer and follow as far as the seasonal conditions will permit. On new land barley or flax is the first crop, following which wheat is grown for two or three years. Barley or flax may follow, and in turn be succeeded by oats. After oats neither wheat nor barley appears to do very well, and flax gives the best results. Where summer fallowing is practiced it should follow oats.

Summer fallowing is practiced to a considerable extent, the land being plowed late in summer, when most of the weeds are in bloom. The two objects that guide this practice are to permit the land to recuperate and to destroy weeds. For the latter purpose frequent harrowing during the season is essential, and this practice also has the advantage of conserving moisture. It is also recognized that a thoroughly cultivated crop like corn or potatoes gives equally as good or better results in the succeeding grain crop as fallowing.

By the best farmers cultivated, fallowed, and new land is sown in wheat, and after fallowing wheat is sometimes grown for two or three seasons in succession. Oats and barley are largely utilized to free land from weeds by overtopping and smothering them with their leafy growth. Oats and emmer are sometimes sown together for feed.

Emmer yields as much as 75 bushels per acre, but is very light and chaffy, and in yield of grain does not materially exceed some of the other crops like barley. Some macaroni wheat is sown, and this crop is growing in favor. A careful farmer who has had experience with it estimates that in a dry season macaroni wheat will exceed the common wheat in yield by about one-third. In other seasons the yields are about the same.

Wheat and the other grains are cut with binders and thrashed from the shock. The stubble is cut high, and when sufficiently thick is burned, after the shocks have been removed, to kill weeds. Two species of mustard, sunflower, foxtail, and a number of other weeds become very troublesome in the grain fields.

Very little corn is grown, and this is frequently injured by early frost, although in some years mature grain is obtained. The principal use of corn is as fodder, but its harvesting conflicts with that of the small grains, and on the same farm the latter are given the preference. The corn should be planted on the lighter, sandy soils, care being given to maintain the moisture supply by frequent cultivation.

Potatoes are grown, but only for home use. The tubers are large, smooth, and of fine quality. Following potatoes, very large crops of grain are obtained.

Cattle and hog raising is confined to a few farmers. The cattle are of the beef type, except a few that furnish the local dairy supplies. The native prairie is used for pasture, and swamp hay and ground small grains are fed in winter. The great bulk of the feed is consumed at home by the many horses that are necessary in farming operations.

Except on a few of the best-managed farms, the manure from the stables is not applied to the land, though largely increased crop returns are realized from its use.

The moisture conditions determine the crop yields in this region, and those practices that concentrate the most moisture within reach of the plant roots give the best results. It is best to plan the management of the land with reference to dry seasons, since they are of more frequent occurrence, and in the wet years the same practices will give good results, though not much larger yields than result from less thorough methods under the prevailing conditions. Plowing to a depth of from 6 to 8 inches provides a larger reservoir for moisture storage than shallower plowing and gives a larger space through which the plant roots may readily distribute themselves. The under part of the furrow slice should be well packed down, so that it will be in close contact with the unturned soil, which process aids in the distribution of water downward in times of rain, hastens the decay of organic matter, and permits the plant roots to extend below the depth of plowing. The deeper the rooting the better can protracted drought be withstood. It should be the aim to get into the soil all of the water that falls and to retain it there until it can be taken up by the plants. To retain moisture the surface should not be left hard, rough, or exposed any longer than is absolutely necessary. It is desirable to plow the land or disk the surface to the condition of a mulch as soon as the crop is removed, and if plowed it should be immediately worked down, and the surface kept loose and fine by the use of a shallow harrow. This applies particularly to fallow and fall plowing. It is said by some farmers that a loose, smooth surface in winter permits the fine top soil to blow and the snow to be carried away by the wind. If surface cultivation is practiced as soon as the soil is sufficiently dry not to puddle, the blowing will be prevented. The blowing of the snow does remove some moisture, but while it is melting the surface of the ground is frozen, so that a comparatively small amount enters the soil, and is more than balanced by the amount conserved by summer cultivation. It might be found advisable in some years to roughen up the surface of the ground late in the fall, so that it would hold the snow.

It is recognized that even in dry seasons those crops that are cultivated seldom fail to make a good growth. This is largely because evaporation from the surface is checked by the loose top soil. Spring harrowing of the grains is practiced on at least two farms in the area with good results. The practice may be continued until the plants begin to joint or reach the stage when they completely shade the ground.

All of the above practices for the accumulation and retention of moisture are to be recommended, but it is recognized that it will not always be practicable to apply them completely. Their use must be governed by the question of economy in each case, but it is believed that if more attention be paid to the conservation of moisture considerably increased profits will result on many of the farms of the area.

AGRICULTURAL CONDITIONS.

The farmers of the Cando area are generally in a fairly prosperous condition. The number of really good houses is not large, although many of the farms have large, substantial barns, and within the last three years many fine farm buildings have been erected. On the remaining farms the buildings are the primitive "shacks" of the homesteading settler. Much machinery of modern patterns is used, and the horses and other live stock are of good types. The acreage of improved land is increasing, and the value of farm land has risen rapidly in the last five years. Much of the debt incurred only a few years ago in establishing new farms is being liquidated, and the amount of land offered for sale is constantly decreasing. The value of land ranges from about $10 an acre for the most remote prairie to $35 or $40 for the cultivated land near the shipping points.

According to the census of 1900, 76 per cent of the farms in Towner County are operated by the owners, and that figure probably represents conditions in the area surveyed. Renting, where practiced, is usually on a basis of a share of the crops, the proportion being one-half of the grains thrashed where the owner of the land furnishes half the seed and pays half of the thrashing bill. At least one large farm is operated by a resident manager.

The average size of farms in the county in 1900 was 289 acres, but the average in the area surveyed will probably exceed that figure considerably. A large number of farms contain from 300 to 500 acres each, several exceed 1,000 acres, three or four exceed 2,500 acres, and one contains 4,300 acres. Land is handled on the basis of the quarter section of 160 acres as a unit, and the price is often quoted by the "quarter."

A large amount of labor is required during part of the year when crops are being seeded and harvested, while at other times only a few men are employed. To meet this irregular demand large numbers of men are imported from other sections of the country. Those employed through the year are engaged by the month at a wage of from $25 to $35. Ordinary day labor is paid from $2 to $3, and where skilled mechanics are employed their wages exceed these figures. Subsistence is also furnished to those employed.

All of the cultural operations are performed on an extensive scale, and each man is expected to handle wide-cutting implements and from 3 to 8 horses. Plowing is done with a double gang plow drawn by 5 or 6 horses. Four horses are used in the ordinary binder, 6 in the rear-draft binders and headers, and 4 in the seeders.

The four grains, wheat, flax, oats, and barley, occupied, in 1900, 99 per cent of the area of all cultivated crops, with relative acreages as follows: Wheat, 62.8; flax, 14.5; oats, 13.9; and barley, 7.9 per cent. Since that date there has probably been a relative decrease in the acreage of flax. Hay is produced from the swamp land and is a natural growth. Thirty-four per cent of the total value of farm products is placed on the market, the remainder being fed to live stock.

Since wheat is the principal product in the area, it is of interest to know the cost of producing a bushel of this grain. On one of the largest farms, where accurate records of operations and expenses had been kept for a series of ten years, the average yield per acre was ascertained to be about 20 bushels, and the cost of production and marketing, aside from a charge for rent on the land, amounted to 41 cents a bushel when 1,000 acres or more were grown, and nearly

47 cents when less than 500 acres were grown. As this farm is probably more carefully managed than the average farm, the cost of production is below and the yield above the average for the area. The soil on this farm is mainly the Clyde loam, with small bodies of Clyde fine sandy loam included.

No attention is paid to the adaptation of soils to crops. Crops are grown wherever the conditions will permit a fair growth to be obtained. The yields are largely influenced by the seasonal moisture conditions, and the same land does not return the same yield year after year. The heavier lowland soil, embraced chiefly in the type Clyde loam, is the most productive for the grains. As a rule, flax succeeds best on the same type of soil, but in some places it is so damaged, it is thought, by the excess of lime in the soil that its growth is uneven.

As the region becomes more intensively cultivated the need of additional crops will be realized. Rape and root crops grow well on the heavier types, and corn and vegetables do best on the heavier parts of the sandy loam. It may be found that leguminous crops and additional grasses can be produced. Some excellent growths of white clover have been observed. These crops will be useful only should the raising of live stock become more important.

The Great Northern Railroad, with the St. John branch line, affords the only facilities for transportation of the products of the area to the markets, which for all of the principal crops are beyond the borders of the State. The county road system is rectangular, with a road legally on each section line, though in reality the roads are not so frequent, because the present population is not sufficiently dense to utilize so complete a system, while on many of the lines there are barriers to travel that can only be removed at large expense. The main roads through the county are improved by grading and bridges, but none of them is surfaced. Most of the heavy hauling of grain and of supplies for remote points is done in the winter when the ground is frozen.

Since the population is essentially an agricultural one, or dependent on agricultural interests, it necessarily follows that the local market for produce is very small. The grain goes east to the mills and to distributing points, and most of the supplies come in from the same source. There are ten elevators at Cando and four at Maza, through which the grain is handled. Most of it is sold directly to the elevator companies, but the farmer may ship his own grain, in which case, at a cost of from 1½ to 2 cents a bushel, the elevator will receive, store to a limit of fifteen days, and place on board cars. Storage charges are 1 cent per bushel per month for short periods and a less rate for a longer time.

SOIL SURVEY OF THE GREELEY AREA, COLORADO.

By J. GARNETT HOLMES and N. P. NEILL.

LOCATION AND BOUNDARIES OF THE AREA.

The Greeley area occupies that part of the Great Plains lying immediately east of the Rocky Mountains in the north-central part of Colorado. Almost all of the area lies to the west of the eighth guide meridian west. The area is irregular in outline, the greatest width north and south being 27 miles and the greatest length east and west about 35 miles. It is bounded on the south by a line running east and west 2 miles north of the first correction line north and on the west by the foothills of the Rocky Mountains. The survey embraces all of the territory originally forming the Greeley Colony tract and includes parts of Weld and Larimer counties.

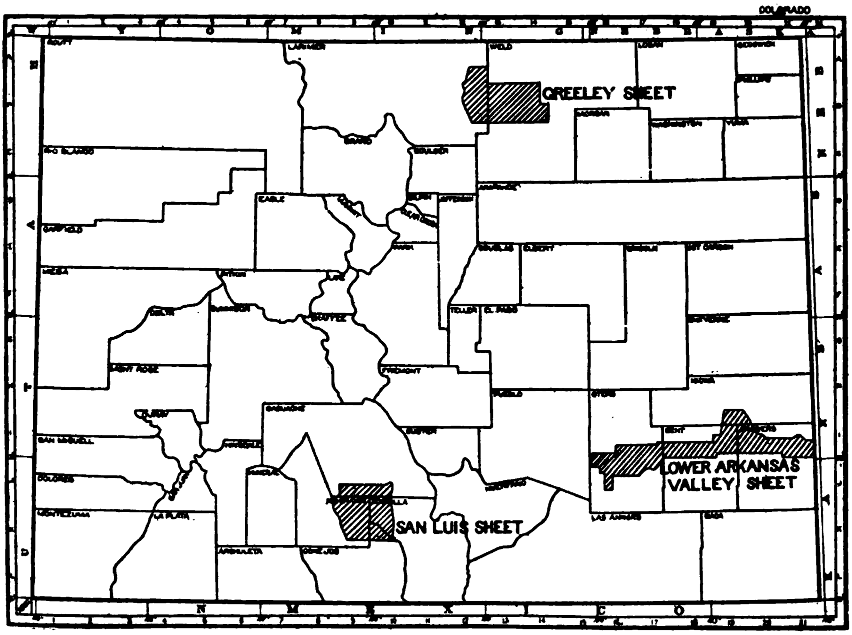

FIG. 40.—Sketch map showing location of the Greeley area, Colorado.

The total area covered by the survey is 439,744 acres, or approximately 687 square miles. Most of this territory is under irrigation. Greeley, Fort Collins, and Loveland are the principal towns in the area.

For many years after the eastern and western coasts were fairly well known and forts and trading posts dotted the great inland waterways of our country, the Great Plains and Rocky Mountain region were as a sealed book. This great semiarid plains region to the west of the Missouri River had no navigable waterways, and no one had the temerity to brave the dangers of an overland expedition. With the return of the Lewis and Clark expedition came Chief Big White of the Mandan Indians. After listening to his stories Ezekiel Williams organized a party of 20 men, who proceeded from St. Louis to Old Fort Mandan, expecting to cross on a trapping trip from this point overland to the Pacific coast. After a great many misfortunes three of this party reached the Rockies along the South Platte in the year 1808. One reached the Arkansas and floated down in a canoe, finally reaching American settlements; the other two crossed the Rockies to southern California. So far as history records, these were the first white men to visit this region.

In 1819 Mr. Stephen H. Long, under the direction of Secretary of War Calhoun, headed an expedition which left the Missouri River at Council Bluffs to explore the Great Plains region. He proceeded along the Platte to the junction of its two branches, where he took the South Fork, which he followed to South Park. After doing some mountain exploration he returned to the Mississippi by way of the Arkansas. He reported all the Great Plains region a desert of sand and stones unfit for cultivation, whereupon it was shown upon maps of that date as the Great American Desert. This report did much to retard the settlement of the country.

The Government did not send any more expeditions into this territory until 1842, when Fremont, taking the route traversed by Long in 1820, reached Fort St. Vrain, which was situated at the confluence of the Cache la Poudre and South Platte rivers, a few miles east of the present town of Greeley. In the interval between the explorations of Long and Fremont powerful fur companies came in and built forts and fur-trading stations all along the streams of the region. Fort St. Vrain was the only one situated in the area recently mapped by this Bureau. It was established in 1838, and was the first white settlement in the area.

As the great trains of emigrants crossed the plains to California in 1849 and later, a few of the gold seekers were diverted to prospect the eastern front of the Rockies by rumors of gold found there. These all remained near defensive establishments and accomplished but little.

In 1856 Mariano Modena, a Mexican, built a small fort on Big Thompson Creek, 4 miles above the present town of Loveland. Here the first artificial products of the area. Later, when the stage line was established between Denver and Old Fort Laramie, his fort was one of the stations. Hay for the horses was cut from natural grasses along Big Thompson Creek, and grain was grown in a limited way for the same purpose.

In the late fifties a few small gold finds were made along tributaries of the Platte. Rumors of these discoveries and the publication of the diary of one of the explorers in 1858, under the title of Pike's Peak Guide and Journal, caused a great caravan of gold seekers and other adventurers to cross the plains in 1859 and the early sixties. Many of these failed to find gold. Many were farmers from the States. Prices for all provisions and feed were enormously high. The valleys of the Poudre and Platte rivers and Big Thompson Creek were low, moist, and produced much natural hay without irrigation. The presence of Government troops at many forts in the plains region had minimized danger from Indian raids, so that those who preferred the sure returns of farming and stock raising to the hazards of gold seeking settled along these streams and engaged in agricultural pursuits. By 1860 there were settled along Big Thompson Creek four or five families, about a dozen along the Poudre from old Fort St. Vrain to the mountains, and three or four families along that part of the South Platte included in the area. These early settlers grew garden vegetables and cut native hay, which produce was hauled to Denver and Central City. All supplies not grown in the valley had to be brought from Missouri River points by wagon train, and were very high priced. There were no mills, and flour sold at from $20 to $40 for a 50-pound sack. For the hay and vegetables sold a correspondingly high price was received. Hay brought from $30 to $90 a ton. All these early settlers grazed stock on the surrounding plains, and were as much stock raisers as farmers. In 1861–62 the first small ditches for irrigation were taken out from the Cache la Poudre and Platte rivers and Big Thompson Creek. Much agitation for local territorial government came in the years from 1858 to 1861, resulting in the organization of the two counties in the survey—Weld and Larimer—in 1861.

In 1865 the settlers for the first time began growing wheat and other grains. Prior to this time only the immediate flat, level bottoms along the streams had been irrigated, but in this year a small cooperative ditch on Big Thompson Creek watered several hundred acres of the high lands.

As late as 1868 frequent Indian scares greatly agitated the settlers and retarded further extension of farms, but no massacres ever took place. In 1861 troops were sent to La Port, the first town on the Cache la Poudre, to protect settlers along that stream. Two years were stationed for some years.

In the early years of farming many trials were undergone by the settlers. In addition to Indian scares the grasshopper plague threatened to drive them out. All the farms were in the small valleys, which were subject to floods. During 1864 one of the most general Indian scares occurred, nearly all the settlers leaving their farms for the protection of neighboring settlements. Floods destroyed their fences and other permanent improvements, and the few crops on high places were completely destroyed by the grasshoppers.

The first wheat was hauled to Golden to mill. Later a mill was built at Boulder, and in 1866 mills were built south of the present site of Loveland, on Big Thompson Creek, at what was then Thompson. These mills gave a great impetus to wheat growing, as the surrounding region furnished a ready market for all mill products.

From 1865 to 1870 many small individual and cooperative ditches were taken out along the streams to irrigate, principally, the bottom lands. About 1865 potato growing began in a commercial way. These early crops were marketed principally at Fort Laramie, Denver, Black Hawk, and Central City.

In the later sixties many eyes were turned to the great semiarid West. The success of the Mormons in Utah and the early Mexican irrigators along small streams in the Southwest had suggested the advantages of irrigation farming. The presence of mining camps in the mountains afforded a ready market and tempted many to come to these new regions.

The greatest impetus agriculture had in this region, however. came not so much from a desire for gain as from a desire to fulfill the socialistic and economic ideals of cooperation enthusiasts. In 1869 Mr. N. C. Meeker, who had had experience in cooperation experiments, and who had written quite a little for the metropolitan newspapers, came to the notice of Mr. Horace Greeley, then editor of the New York Tribune. Mr. Meeker was engaged to make a tour through Kansas and Colorado to Utah, at which point he was to investigate particularly the cooperative features of the Mormon settlements. Heavy snows on the Union Pacific Railroad prevented him from reaching Utah, but he returned to New York imbued with the thought that the large, practically unsettled regions of the semiarid West presented peculiar features that would make possible the fulfillment of his ideals of cooperative settlements. Horace Greeley heartily sanctioned the scheme. A call was issued in the Tribune for members to join a projected colony whose location was not yet decided. All classes of sober, temperate citizens were called upon to respond. The result was the formation in New York of the Greeley Colony organization. A location committee sent to Colorado, Utah, and

Wyoming to select a site decided upon the present site of Greeley, along the Cache la Poudre, and in the spring of 1870 the first colonists arrived. Because of the cooperative features, the interest taken in the colony by Mr. Greeley, and the consequent wide publicity given the undertaking in his paper, the colony became widely advertised. Next to the work of the Mormons it proposed the most extensive irrigation works in the United States. Attention was attracted in every part of the United States, which led to the quite rapid settlement and development of the lands adjoining those of the colony.

The Union Pacific Railroad having been completed in 1868, a branch line, the Denver Pacific, was projected and almost immediately built from Denver to Cheyenne, bringing railroad transportation directly to this area. Old canals were enlarged and new ones, planned to cover practically all the territory now farmed, were soon afterwards constructed.

Like so many other cooperative and colonistic schemes, Greeley Colony as such soon disbanded, and all lands and other holdings passed into private hands. The canals formed an exception, being still administered cooperatively.

Before the disbandment of the colony, however, a number of other settlements or colonies patterned after Greeley were established along the Cache la Poudre and the Platte. Chief among these was what is now the town of Fort Collins. In 1872 this was a small insignificant settlement. Several of the early colonists at Greeley conceived the idea of making of it a colony similar to Greeley. It was called Agricultural Colony, but, as in the case of the Greeley Colony, the organization soon disbanded.

In 1882, when a railroad had connected Greeley and Fort Collins, the intermediate town of New Windsor was founded. The Larimer and Weld canal having been extended to take in lands along the Denver Pacific, the town of Eaton, 8 miles north of Greeley, was started. In 1875 the present town of Loveland was established, and in that year a mill and a grain elevator were put into operation. Other mills quickly followed at Greeley, Fort Collins, Eaton, and New Windsor.

Up to about 1890 wheat, oats, barley, potatoes, and garden vegetables were the principal cultivated crops grown throughout the entire area. Native hay was cut extensively along the bottom lands. During these years of poor rotation the productivity of the lands, despite great quantities of manure that were added, became greatly reduced. Some resorted to stock raising, principally for the benefits accruing to the land from the use of manure. In the later eighties a few began the growing of alfalfa. Its use as a beneficial crop in the rotation was little understood. Because of imagined difficulties of getting rid of the crop its introduction met with great resistance, but a few successes soon demonstrated that it could be easily handled as a rotation crop and quickly led to its universal use, until at present it is one of the most important crops grown. It has not only paid in the hay produced, but has resulted in the restoration of the productiveness of the soils to such a degree that as large yields of wheat and potatoes are now produced as in the early seventies from the virgin soils. The introduction of alfalfa marks the greatest epoch in agriculture the valley has yet seen.

Experience having demonstrated that sugar beets were suited to the region, a factory was built at Loveland in 1900. To secure this the citizens gave a bonus of $10,000 and 1,500 acres of land. The introduction of sugar-beet growing resulted in the utilization of much of the lands that had become slightly alkaline, and their culture has proved very remunerative. Quickly following the factory at Loveland others were built at Fort Collins, Greeley, New Windsor, and Eaton. These factories have meant much to the country, and have introduced a new crop into the rotation. Their installment marks another epoch in the history of the agriculture of the region.

As the country has developed and greater shipping facilities have become necessary, some small villages have been built up at the various switches and sidings. Lucerne, Ault, and Timnath are chief among these. Lucerne is about halfway between Greeley and Eaton; Ault 4 miles northwest of Eaton, and Timnath about midway between New Windsor and Fort Collins.

In 1902 a branch line railroad was extended from Fort Collins along Boxelder Creek to afford an outlet for the beets grown in that valley. Since that time the small village of Wellington has sprung up at its terminus.

The old towns of Bellevue and Laporte, along the upper Cache la Poudre, have never grown beyond country post-offices.

For a great many years Evans, in the southern part of the area on the Denver Pacific Railroad, rivaled Greeley, but in recent years it has had little growth, and remains practically the same in population as twenty years ago, a mere village of three or four dozen families.

CLIMATE.

The climate of the Greeley area is semiarid. The moisture-laden winds coming in from the west lose most of their humidity in passing over the mountains lying to the west, and this is the cause of the light precipitation in the area.

The source of most of the rainfall of the area is in the east winds. As they reach the mountains and rise to pass over them their moisture is condensed and precipitated, the greater amount falling nearer the mountains. This fact is brought out by a comparison of the amount of rainfall at Greeley and at Fort Collins, the annual preformer.

According to the records of the Weather Bureau taken at Fort Collins and Greeley, the normal precipitation is 14.68 and 11.92 inches, respectively. At Fort Collins the period of heaviest rainfall occurs during the months from April to September, inclusive, the normal for the six months being 1.81 inches. During April and May the heaviest precipitation of the season occurs, the normal for April being 2.13 and for May 2.90 inches.

At Greeley the rainy season occurs during the months from April to July, inclusive, the monthly average in this case being 1.77 inches. The rainfall during the summer months is insufficient to mature the crops, so that irrigation is practiced generally throughout the growing season.

Severe hailstorms are a very destructive feature of the climate of this locality. They are generally accompanied by high winds. During the season of 1904 the authors observed a severe storm of this character. It occurred early in July and covered a strip of territory about 1 mile wide, crossing the area in a northeasterly and southwesterly direction, touching the town of Greeley. The crops over which this storm passed were all severely damaged. The grain crops were completely destroyed, but the potatoes and beets partially recovered from the effects of the storm and fair yields were secured. These storms are a great drawback to the agriculture of the area, for hardly a season passes without a storm of this character. They are likely to occur at any time during the growing season, and at any place. They are not as a rule general, but usually cover a strip of territory varying from 1 to 4 miles in width.

The prevailing winds are generally from the northwest, and during the fall months they frequently become quite severe, often developing into dust storms, which usually last two or three days.

December, January, and February are the coldest months of the year, the normal temperature being 29.3° F., 26° F., and 26.2° F., respectively, at Fort Collins, and 27.5° F., 25.1° F., and 26.8° F. at Greeley. The warmest period of the year occurs during June, July, and August, the average normal temperature for the period being 67° F. at Fort Collins and 69.4°F. at Greeley. The average normal yearly temperature for the two stations is 47.4° F.

The growing season lasts about five months. The average date of the last killing frost in the spring is May 6 at Fort Collins and April 30 at Greeley. The average dates of the first killing frost in fall at the points named are September 23 and September 25, respectively.

The following table gives the normal monthly and annual temperature and precipitation as compiled from Weather Bureau records taken at Fort Collins and Greeley:

Normal monthly and annual temperature and precipitation.

Month.	Fort Collins.		Greeley.		Month.	Fort Collins.		Greeley.	
	Temperature.	Precipitation.	Temperature.	Precipitation.		Temperature.	Precipitation.	Temperature.	Precipitation.
	° F.	*Inches.*	*° F.*	*Inches.*		*° F.*	*Inches.*	*° F.*	*Inches.*
January	26.0	0.57	25.1	0.26	August	67.8	1.18	70.1	0.98
February	26.2	.57	26.8	.44	September	59.6	1.21	61.0	.88
March	35.7	.94	36.2	.63	October	48.2	.95	49.4	.76
April	45.8	2.13	47.7	1.83	November	35.2	.41	36.0	.57
May	55.3	2.90	57.3	2.19	December	29.3	.37	27.5	.32
June	64.4	1.59	67.1	1.36	Year	46.9	14.68	47.9	11.92
July	69.0	1.86	71.1	1.70					

In general, however, the climate of this section of Colorado is very agreeable and healthful throughout the year. One of the characteristic features is the prevalence of sunshine. A few cloudy days occur, but usually not over three days in succession during the growing season. The summers are mild and pleasant, extremely hot days being of rare occurrence. The winters, though the temperature often falls several degrees below zero, are not severe. The dryness of the atmosphere, together with the prevalence of sunshine, prevents the extremely low temperatures from being felt as they would be in more humid sections. During both the summer and winter months the climate is invigorating, and especially helpful to those suffering from pulmonary complaints.

PHYSIOGRAPHY AND GEOLOGY.

With reference to its physiographic features the Greeley area falls naturally into two distinct divisions—the river valleys proper and the uplands. The surface features of the uplands in general consist of rolling and undulating prairies, with occasional low hills and ridges. The slope of these hills and ridges is, as a rule, not so excessive but that with proper management they can for the most part be profitably cultivated. The general slope of the area is to the southeast, the elevation ranging from 5,000 feet in the eastern portion of the area to about 5,500 or 6,000 feet above sea level near the western boundary. The hills which mark the western boundary rise abruptly out of the plains, and attain an elevation of from 8,000 to 9,000 feet above sea level.

Since the formation of the plains in this part of Colorado, erosion has been rapidly at work in the degradation and removal of the original material, resulting in the formation of well-rounded hills and low ridges, bluffs, and terrace lines, small valleys, and occasional deep arroyos. The soils of the area are generally quite deep, but occasional rock outcrops are seen along the bluffs and terrace lines.

North of the Larimer County Canal the surface is extremely rolling and undulating. This territory is above the irrigable districts, and is for the most part covered with the native grasses of the plains. South of this canal and extending to the bottom lands of the Cache la Poudre River the surface assumes a more level appearance, still maintaining, however, its undulating character, and interrupted by occasional small hills and ridges.

The many small streams, which are usually of intermittent character, and which traverse this portion of the area in a southerly direction, have formed small valleys 30 to 50 feet lower than the surrounding country and from one-sixteenth to one-fourth of a mile in width. As the streams approach the river their valleys usually become wider and shallower, sloping gently to the hills on each side. In the eastern part of the area, bordering the valleys of Owl and Lone Tree creeks, the surface is comparatively level, with occasional low hills and ridges. The valley floors of these streams slope gradually toward the stream beds, and are cut by numerous old stream channels, sloughs, and swampy areas. East of the valley of Owl Creek the surface again assumes a rolling and undulating appearance.

The boundary between the uplands and the Cache la Poudre Valley proper is marked north of the river in places by steep bluff lines, while in other places a more gradual slope prevails with low, minor ridges or terrace lines, each terrace representing the boundary of a former flood plain. South of the Cache la Poudre River the surface features are very similar to those north of this stream. In general, this part of the area represents a broad ridge between the Cache la Poudre and Big Thompson Creek. The surface of this broad ridge consists of rolling, and in some instances extremely undulating uplands with a general fall to the southeast. The terrace line marking the boundary between this part of the uplands and the river bottoms is very irregular. In some instances it is marked by steep bluffs, but in others the slope is gradual and cut by numerous small washes or gullies. In most cases the rise is quite abrupt, the elevation varying from 25 to 50 feet above the level of the river. The greater proportion of the drainage waters of this territory runs into the Cache la Poudre River, only a small amount reaching Big Thompson Creek.

The surface of the uplands is dotted by numerous natural and artificial lakes and local depressions or drainage basins. In the northwestern part of the area some of these lakes are connected in chains or groups, forming excellent storage reservoirs, for which they are mainly used. A number of these lakes and drainage basins are of an intermittent character, containing water only during the rainy season. As the western boundary of the area is approached, and especially along the base of the foothills, the surface becomes extremely undulating, presenting hills, ridges, and valleys prominently developed. The ridges have been given the local appellation of "hogbacks." The most prominent ridge occurs near the western edge of the area, north of the Cache la Poudre River. Between this ridge and the mountains is a comparatively level valley which has been formed by a small mountain stream. This ridge generally slopes gently to the east, while its western edge inclines at a very high angle, and in some cases is nearly vertical.

The sedimentary hills and ridges occurring along the base of the mountains south of the river have been cut through, generally at right angles to the trend of the strata, by numerous small streams that flow down from the mountains. These have formed small, shallow valleys, and in some instances rather deep arroyos. The streams are intermittent, being dry the greater part of the year. Where Big Thompson Creek and the Cache la Poudre River emerge into the plains great notches have been cut in the eastern front of the mountains.

The principal valley of the area occurs along the Cache la Poudre River. It varies from one-half to more than 1 mile in width, and is from 75 to 100 feet lower than the adjacent uplands. Along parts of the valley the sides are rather steep and sometimes precipitous bluffs, while in other places they are formed by more gentle slopes. The character of the surface of the valley formed by Big Thompson Creek is similar to that just described. The valley of the South Platte River, in the southeastern part of the area, is much wider than either of those just mentioned, and is bounded, as a rule, by more prominent bluffs.

The surface of these valleys is comparatively level, with a gradual fall from the margins toward the stream beds. The bottoms are subject to annual overflow, and are cut by old stream channels, sloughs, and swampy areas. A few low hillocks and ridges, seldom exceeding an elevation of 3 or 4 feet, occur in different parts of the bottom lands.

All of the lines of drainage of the area lead to the South Platte River. The principal stream is the Cache la Poudre River, which traverses the area in a southeasterly direction and empties into the South Platte about 5 miles east of Greeley. It receives the greater proportion of the drainage waters of the area from the numerous minor streams which flow into it both from the north and the south. These streams flow through small valleys and are fed mainly by seepage from the soils. As already stated, the channels of many of the small streams are dry the greater part of the year, containing water only after continued wet periods. During the wet season there is generally a very strong flow of water, and the surface drained by these streams often suffers greatly from the effects of erosion.

Big Thompson Creek receives the drainage waters of the southwestern corner of the area. It traverses the area for only a comparatively short distance, and receives only a small portion of the drainage waters. The South Platte River, which crosses the southeastern portion of the sheet, enters the area about 1 mile east of Evans, flows in a northeasterly direction to its confluence with the Cache la Poudre, and thence southeast, passing out of the area about 1 mile north of the southeast corner of the area. It receives all of the drainage waters of the area.

The geological formations of the area are comparatively simple and easily understood. With the exception of a small strip of territory bordering the western edge of the area, the underlying rock formations consist chiefly of alternating beds of sandstone, limestone, and shale, classified by Hayden as rocks of the Cretaceous and post-Cretaceous periods. These were laid down one after the other in the bottom of a vast ocean that once covered this region. These beds vary considerably in thickness, and lie in nearly horizontal strata, inclining slightly to the east at about the same slope as the plains.

Underlying the Cretaceous rocks are found those of the Jura-Triassic, which consist chiefly of a series of arenaceous beds, called by Hayden the red arenaceous deposits or Triassic. The deposits are exposed along the western edge of the sheet, and form one of the most conspicuous features of the geology of the area. They contain both salt and gypsum, the latter mineral often in great quantities, and are sometimes referred to as saliferous or gypsum-bearing beds. Mixed with these beds are several layers of bluish siliceous limestone, which in the northern part of the area are generally quite thick, but gradually thin out to the southward or are covered over by débris. These limestone strata are most prominent in the formation of the Colorado gravelly loam, although some of the rocks of the older formation to the westward have contributed to a certain extent to the origin of this soil.

The rocks of the Cretaceous period are classed under three groups. The Dakota group, which is the lowest of the series, occurs as a long, narrow strip, exposed in the western part of the area. It rests directly upon the Jurassic beds, and partakes of about the same stratigraphical features, but owing to the hardness of the strata forms more persistent "hogback" ridges than any other formation. This group consists of clean, gritty, even-grained sandstones, varying from a siliceous conglomerate to a hard quartzite. Beds of argillaceous shales, often containing carbonized vegetable matter, alternate with the layers of sandstone. The color of the rocks of this group varies from a light gray or white to a rusty yellow, and occasionally to a red in the softer parts.

The Fort Benton group rests upon the upper members of the Dakota. This group consists of arenaceous clays with three layers of argillaceous sandstone, passing into highly laminated black or gray shales. The whole group is quite homogeneous in character, and often attains a thickness of from 200 to 600 feet.

The Niobrara group lies above the Fort Benton group. The lower members are a series of limestone and calcareous shales, while the upper part is composed mainly of dark-gray shales, often arenaceous, and containing many layers of sandstone with some concretions.

Overlying this group and marking the close of the Cretaceous period is the Fox Hills group. It is composed of dark, soft shales, which are followed by a whitish sandstone. This is in turn covered by a succession of gray to yellowish-brown shales, alternating with a series of similarly colored sandstones. This group occupies a comparatively wide strip of territory east of Fort Collins, and is particularly prominent in the origin of the soils of the uplands northeast of Loveland.

Covering a little more than the eastern half of the sheet and lying above the Cretaceous formations is the post-Cretaceous. It is described by Hayden as the transitional layer between the marine beds of the Cretaceous and the fresh-water deposits of the Tertiary. It is composed mainly of ordinary indurated sandstones, together with beds of carbonaceous shale and coal. This formation, designated by geologists as the Laramie group, is regarded as the coal-bearing series proper of the Rocky Mountains. In the northeastern part of the area a few small coal mines have been opened, but the coal produced is not considered valuable for general purposes. It is used largely by the pumping plants, and the quality is considered good enough for this purpose. The coal produced is sold for about $2.50 a ton at the mines. The mines are owned by individuals and are not as yet extensively developed.

The soils of the bottoms belong to the recent Alluvium of the Quaternary. The areas are not extensive, being seldom over 1 mile in width along Big Thompson Creek and the Cache la Poudre and South Platte rivers.

SOILS.

The soils of the Greeley area divide themselves naturally, according to the two main physiographic features, into upland types and river bottom types.

The upland soils are for the most part of residual origin, having been formed by the disintegration of the rocks upon which they rest.

Only one type of the upland soils is strictly of colluvial origin—that bordering the foot slopes of the Rocky Mountains. The upland soils, as a rule, show no general stratification. The mineral constituents of these types are very similar in character to those of the parent rock, and in some instances, especially in the fine sandy loam type, the soil extends to bed rock without marked variation in texture or structure.

The river-bottom types are true alluvial soils. The mineral particles and rock fragments composing these types are, as a rule, more varied in character than those of the colluvial and residual soils of the uplands, and the soils in general show partial stratification.

In the area represented on the map accompanying this report not only are colluvial, residual, and alluvial soils represented, but a number of varieties of each, classified according to their textural differences, physiographic positions, and relative crop values.

The soils of the area, as a rule, are very productive, and with the exception of the lighter and coarser areas, possess marked moisture-retaining properties, which greatly increase their agricultural value.

The following table shows the area of each of the types recognized and the proportion each forms of the total area surveyed:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Colorado fine sandy loam	196,480	44.8	Fort Collins loam	14,144	3.2
Colorado loam	78,784	17.9	Billings clay loam	12,800	2.9
Billings loam	41,984	9.6	Colorado adobe	5,632	1.2
Laurel sandy loam	33,792	7.7	Billings silt loam	4,032	.9
Colorado gravelly loam	33,408	7.6	Total	439,744	
Colorado sand	18,688	4.2			

LAUREL SANDY LOAM.

The Laurel sandy loam is an alluvial soil ranging in depth from 2 to 5 feet. The texture of this type is subject to considerable variation, depending largely upon the position occupied. It consists of two phases—a sandy phase and a loam phase—the latter not occurring in areas large enough to warrant classification as a separate type.

The lighter phase, which forms the greater area of this soil, varies from a coarse sandy loam to a fine micaceous sandy loam, each variation existing in such small areas and so interbedded that it was impossible to outline them separately. The soil generally becomes more sandy with depth, passing gradually into coarse sand and water-worn gravel. In some instances, however, it grades into a stratum of heavy, black, tenacious clay loam, a few inches in thickness, which is underlain by sand and gravel.

The heavier phase consists of a loam to a depth of about 3 feet. It occurs only in small areas or local patches occupying depressions which represent old sloughs and former stream channels. The line of demarcation between the soil and subsoil is often very sharp, the transition from loam to coarse sand and gravel taking place within 2 or 3 inches.

Organic matter is present in large quantities in the soil and imparts to it its characteristic dark-brown or black color.

Small sand and gravel patches occur scattered over this type in the form of low ridges or hummocks. Near these ridges and bordering the streams gravel is found in varying amounts, scattered over the surface and through the soil. The subsoil consists of coarse sand, which grades into coarser sand and waterworn gravel at lower depths. The color, as in the soil, varies from light to dark gray, depending upon the amount of organic matter present.

The following table gives the results of mechanical analyses of typical samples of this soil:

Mechanical analyses of Laurel sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12080	Cen. W. side sec. 34, T. 8 N., R. 69 W.	Black fine sandy loam, 0 to 36 inches.	1.5	5.1	3.5	29.3	26.7	27.5	6.2
12079	¼ mile NW. of SE. cor. sec. 24, T. 5 N., R. 69 W.	Black fine sandy loam, 0 to 36 inches.	.6	5.7	7.4	28.7	22.8	26.3	8.3

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 12079, 1.87 per cent; No. 12080, 1.2 per cent.

The main bodies of this soil occupy the valley floor proper of Thompson Creek and Cache la Poudre and the South Platte rivers. It occurs as a narrow strip, averaging about three-fourths of a mile in width along these streams throughout their entire course across the area. One small fingerlike patch occurs along Lone Tree Creek, extending up that stream for a distance of 2 miles from the main body bordering the Cache la Poudre River.

The topographic features of the areas covered by this type of soil are not very marked. The surface is comparatively level, with a gradual slope toward the streams. It is cut by numerous sloughs, old river channels, and small swamp areas. The sand and gravel ridges or hummocks already mentioned occur over the surface, but these rarely exceed an elevation of 3 or 4 feet. The boundaries of this type of the mesa lands.

Owing to its low-lying position and to seepage from the irrigated uplands the drainage of this type, except in the higher areas, is comparatively poor. During wet seasons much of it is subject to overflow from the streams which it borders. The water table is near the surface the greater part of the year, and at the time the survey was made the depth to ground water rarely exceeded 6 feet.

The Laurel sandy loam is of alluvial origin, having been deposited in comparatively recent time by the Cache la Poudre and South Platte rivers and Big Thompson Creek. The heavier phase of the type was deposited in those places where the streams were at one time sluggish or had their flow checked by obstructions, and has been modified by the washings of finer materials from the higher levels into the depressions.

Only small areas of this soil are affected by alkali. In most cases the percentage of alkali is small, the worst affected areas rarely containing more than 0.40 per cent for the 6-foot profile. The greater part of these salts generally occurs in the first and second feet. Surface accumulations are found over the area in which the first foot contains the largest percentages, but the quantity found in these places is seldom sufficient to injure vegetation.

The Laurel sandy loam is rich in plant food, and where unaffected by alkali is well adapted to small fruits, grains, truck crops, and native hay. It is particularly well suited to the growing of cabbages, onions, and sugar beets, and is generally considered one of the best beet soils in the area, producing good yields, with a high percentage of sugar. Tomatoes and potatoes do well upon this soil where it is fairly well drained. Potatoes are not, however, grown extensively, on account of their tendency to rot during wet periods. Oats and wheat are not sown to any great extent, because they produce too rank a growth and the grain often becomes lodged. On the higher levels and in well-drained areas generally alfalfa thrives, but its production on the lower or poorly drained areas is not to be recommended unless a thorough drainage system is first established. The type is not well adapted to the larger tree fruits, but plums and cherries can be successfully grown. It is well adapted to such small fruits as strawberries and raspberries, and a considerable part of the type is devoted to their production. Good yields are generally obtained, and the fruit is of excellent quality.

The yields of the various crops grown on the Laurel sandy loam vary considerably with the character of the seasons and the methods of cultivation. Under ordinary conditions, where a stand is secured and the grain does not lodge, oats average 60 bushels to the acre, though crops have been harvested that yielded as much as 110 bushels per acre. Barley averages about 50 bushels, while wheat lodges as a rule, so that only fair yields are obtained. Onions yield 300 sacks of about 110 pounds each; cabbage, 15 to 20 tons; potatoes, 200 bushels in favorable seasons, and sugar beets from 15 to 20 tons per acre. Alfalfa yields about 5 tons, three or four cuttings being obtained in a season. The average yield of hay, consisting of the native grasses, chief among which are wire grass, salt grass, and blue stem, is about 1 ton per acre.

BILLINGS CLAY LOAM.

The Billings clay loam is the heaviest type of soil found in the present survey. It consists of a uniformly heavy loam or clay loam, varying in depth from 2 to 5 feet. The clay content increases with depth, and at from 8 to 15 inches the soil becomes very compact and tenacious. The color ranges from dark gray to black, the latter predominating.

The subsoil of this type, unlike the soil, is subject to considerable variation in texture, ranging from a heavy sandy loam to coarse sand and fine gravel. Along the streams and extending back on each side for some distance the subsoil is composed mainly of sand and gravel. Higher areas farther away from the streams, and bordering the outer margins of the type, are generally underlain by a stratum of heavy sandy loam, which gradually increases in depth with the distance from the stream, and in general, as the outer margin of the type is approached, extends to a depth of 6 feet or more.

The color of the subsoil varies from gray to black, depending largely upon the texture, the loamy phase being the darker. Considerable organic matter is present in both the soil and subsoil.

The following table gives the mechanical analyses of typical samples of this soil:

Mechanical analyses of Billings clay loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12072	SW. cor. sec. 2, T. 7 N., R. 65 W.	Brown loam, 0 to 36 inches.	0.2	2.0	2.8	16.4	16.5	36.3	26.1
12074	4 miles E. of Lucerne	Brown clay loam, 0 to 48 inches.	.3	1.4	1.4	10.2	12.9	46.1	27.6
12073	Subsoil of 12072	Light loam, 36 to 72 inches.	.4	2.0	2.7	19.0	20.6	31.4	23.6

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 12072, 3.3 per cent; No. 12073, 6.1 per cent; No. 12074, 1.9 per cent.

The Billings clay loam occupies only a small portion of the area surveyed. The largest area mapped borders Lone Tree and Owl creeks. The remainder of the type occurs in small areas along the intermittent streams.

In general the surface of this soil is comparatively level, with gentle slopes toward the bordering streams. The surface is cut to some extent by sloughs, former stream channels, and small swampy areas. Near the streams small gravel ridges are found, varying in height from 2 to 4 feet.

The natural drainage conditions of the greater portion of this type are very good. The underlying sand and gravel afford an excellent medium for carrying off the surplus water, and the areas are generally high enough above the streams to give adequate fall for surface drainage. It is only during periods of excessive rainfall that this soil is overflowed. However, a few small swampy and poorly drained areas occur near the beds of streams. The water table is found at a depth varying from 2 to over 10 feet.

The origin of the Billings clay loam is distinctly alluvial, the component materials derived from various sources having been deposited by the streams within recent times. The soil of the largest area, occurring in the northeastern part of the sheet, is composed largely of decomposed shale, as shown by the presence of a large quantity of shale fragments on the surface in the northern part of this area. The material composing the other areas has been derived mainly from washings from the surrounding higher levels, but contains a greater or less proportion of sediment brought down from the north. The sand and gravel composing the subsoil have undoubtedly been transported to their present position from gravelly areas far north of the area surveyed.

This soil is practically free from injurious amounts of alkali. A few of the lower areas show some accumulations, especially where the water table is near the surface, but the amount rarely exceeds 0.40 per cent for the entire 6 feet. The percentage for the first 3 feet is sometimes much higher than this, in some instances reaching 1 per cent. Slight surface accumulations occur over some of the wet and poorly drained areas, but the amount is generally insufficient to injure the vegetation in these places, usually consisting of the native grasses.

Gypsum also occurs to some extent throughout this soil, especially where it is alkaline. The higher areas of the type are well suited to the production of alfalfa, wheat, oats, potatoes, and sugar beets; while the lower areas are adapted to native hay, and are largely used for this crop, especially along the streams. The soil is very difficult to cultivate and requires much labor to put it in proper condition for sowing the crops, but if good tilth is secured before planting satisfactory yields are generally obtained.

During favorable seasons alfalfa yields from 2 to 4 tons per acre from three cuttings, wheat from 15 to 25 bushels, oats about 60 bushels, and potatoes from 100 to 200 sacks per acre. Sugar beets are not grown to any extent on this type. The soil is undoubtedly well suited to this crop, and the yields compare favorably with those secured on the Laurel sandy loam. The average yield of native hay is about 1 ton per acre, varying from three-fourths ton to 1½ and sometimes 2 tons.

COLORADO FINE SANDY LOAM.

The Colorado fine sandy loam consists of a fine sandy loam with a depth of 3 feet, underlain by a heavy fine sandy loam or loam to a depth of 6 feet or more. The depth of the surface soil varies considerably, ranging from 2 to 4 feet, and in some instances extending to a depth of 6 feet. In some localities, where this soil has been washed by rain and irrigating waters, the material composing it is mainly a medium sandy loam. In other places the finer material has been washed into depressions, the resulting soil approximating a heavy fine sandy loam or loam extending to a depth of over 6 feet, and mixed with varying amounts of organic matter.

In general, as the depth of the soil increases the silt and clay content becomes greater. At varying depths a zone of heavy sandy loam or loam is almost invariably encountered. It varies in thickness from 1 to 3 feet, and is in turn underlain by material very similar in texture to that of the surface soil. The color of the greater part of this soil ranges from light to dark brown. In the low areas the color, as a rule, is much darker, varying from a dark gray to almost black, depending upon the amount of organic matter present. Some gravel is occasionally found scattered over this type, but it does not occur in sufficient quantities to be of any importance.

The following table gives the mechanical analyses of samples of this type:

Mechanical analyses of Colorado fine sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12061	6 miles N. of New Windsor.	Brown fine sandy loam, 0 to 18 inches.	0.6	2.2	1.5	21.7	39.1	25.2	9.6
12062	¼ mile S. of NE. cor. sec. 10, T. 7 N., R. 69 W.	Fine sandy loam, 0 to 36 inches.	.8	3.5	2.4	17.4	30.7	32.0	13.0

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 12061, 0.68 per cent; No. 12062, 5.3 per cent.

mapped, covering more than one-third of the total area surveyed, occupies most of the upland portion of the Cache la Poudre and South Platte valleys. The most extensive body occurs northwest of Greeley, extending north from that town to the northern limits of the survey, and west to an irregular line about 4 miles east of Fort Collins. The southern boundary of this large area is marked by the bottom lands of the Cache la Poudre River. Another and much smaller area occurs east of the valleys formed by Owl and Lone Tree creeks, and extends south to the river soils of the Cache la Poudre and South Platte rivers. Its eastern and northern boundaries extend beyond the limits of the survey. Only comparatively small areas of this type occur south of the Cache la Poudre and South Platte rivers. The largest body found in this part of the area extends west from the town of Greeley as a narrow strip about one-half mile in width, bordering the northern edge of the mesa lands. Another small body occurs in the vicinity of Kersey. A few areas of very limited extent occur as isolated patches over the eastern half of the sheet.

The surface of the Colorado fine sandy loam presents the most prominent physiographic features of any of the soils surveyed. In general, it varies from rough, hilly, and rolling uplands to slightly undulating plains, sloping gently toward the streams. Most of the rough hilly areas occur north of the Larimer County Canal. South of this canal the surface assumes a more level character, which it maintains until it reaches the river bottom soils. The line of demarcation between this soil and others is often marked by abrupt rises, varying from 2 to 4 feet in height, and in some cases by precipitous bluffs 15 to 25 feet high. Numerous small and generally intermittent streams flow across the areas occupied by this type and have cut out narrow V-shaped valleys. These valleys are as a rule continuous in crossing the area, but in some instances they have been dammed and made into small reservoirs, or are shut off by lakes into which the streams empty. The valleys vary in width from one-sixteenth to over one-fourth of a mile and in depth from 10 to 50 feet. As the main stream is approached they generally become more shallow and are marked by more gentle slopes. The surface is dotted by swampy areas and many natural and artificial lakes varying in size from 25 to over 1,000 acres. Many of these lakes are being used as reservoirs for the storage of water for irrigation. During the greater portion of the year many of the lakes are dry, and the bottoms generally contain a much heavier type of soil.

The loose texture of the Colorado fine sandy loam, together with its rough, hilly, or slightly undulating surface, affords excellent natural drainage. In some instances, and especially on the lighter phases of the more elevated areas, the natural drainage is excessive, and the lands have to be irrigated very frequently in order to produce good crops. The soil is generally of sufficiently coarse texture to permit the rapid percolation of water, so that a large percentage is absorbed by it. During heavy rains, and especially after the land has been thoroughly irrigated, the surplus water readily finds its way into the numerous small streams which flow across the type and empty into the river. It very frequently happens, however, that during periods of this kind the soil washes to some extent, forming shallow gullies on the slopes of the uplands. In a number of instances it was observed that during a single heavy rainstorm the stream beds had been filled to a depth of over 1 foot with eroded material from the higher levels. To prevent this excessive erosion is an important problem with the farmers.

The type in general is but little affected by seepage waters, but in the draws and local depressions adjacent to the canals and heavily irrigated lands the drainage conditions are poor, often necessitating the construction of artificial drains to reclaim such areas.

The Colorado fine sandy loam is of residual origin, the material being derived from the disintegration of the underlying sandstone, shaly sandstone, and shales. The heavier phase of the type owes its origin to the disintegration of the finer grained rocks.

Except in the draws and local depressions affected by seepage, alkali does not occur in sufficient quantities to injure crops. Over some of the more level areas of the higher lands slight surface accumulations occur, but the amount is generally so small as to be of little consequence. In the low seepage areas alkali is found in the soil in varying amounts, ranging from 0.20 to 0.60 per cent, the greatest amount generally occurring in the upper part of the soil. A number of the lakes are slightly alkaline, and a slight surface accumulation of alkali often covers the soil immediately surrounding them. Gypsum crystals are also found in this soil, but only in small quantities.

The Colorado fine sandy loam is especially well adapted to the production of wheat, oats, barley, alfalfa, and potatoes. For the production of potatoes it is considered the best in the area, and a large proportion of the best lands of this type is devoted to that crop. The average yield per acre of potatoes is about 175 sacks of 2 bushels each, although much higher yields are very often obtained. During favorable seasons the average yields per acre of the other crops are about as follows: Wheat, 30 bushels; oats, 50 bushels; barley, 25 bushels, and alfalfa, about 3½ tons from the three crops usually obtained in a season. Sugar beets are grown extensively on the areas that are only slightly undulating or sloping, and on these areas produce an average of about 12 tons per acre.

The uncultivated areas of the type are generally covered with the native grasses, which are used for pasturage.

COLORADO ADOBE.

The Colorado adobe is a typical adobe soil. The mechanical analyses show it to be composed largely of silty material, and under field conditions it appears to be a heavy soil. In the local depressions the soil is very heavy, the silt and clay content being much greater than in the surrounding areas. Under cultivation the surface soil of the upland phase has, in general, the appearance of a loam, and on some of the lighter areas it resembles a heavy sandy loam, still possessing, however, its adobe structure.

The Colorado adobe is characterized by its stickiness when wet, and, considering its heavy texture, by its perviousness to water. The soil takes water readily when subjected to heavy applications, and on drying breaks up into roughly cubical blocks, varying in size from a fraction of an inch to an inch in diameter.

The soil is generally over 6 feet deep, and is underlain by shales or shaly sandstone. Northeast of Eaton the underlying strata contain beds of coal. The type varies in color from dark gray to black in the local depressions, and from light to dark brown on the uplands. Considerable organic matter is present in the soil, especially in the lower areas.

The following mechanical analyses show the texture of the typical samples of this soil:

Mechanical analyses of Colorado adobe.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
12075	W. side sec. 20, T. 6 N., R. 68 W.	Fine sandy loam, 0 to 14 inches.	0.1	0.6	0.7	18.9	30.9	36.0	12.6
12078	NW. cor. sec. 29, T. 6 N., R. 68 W.	Silty clay, 0 to 36 inches..	.0	.2	.2	5.8	10.0	56.8	26.9
12076	Subsoil of 12075......	Brown clay loam, 14 to 28 inches.	.1	.2	.3	9.8	20.9	39.6	29.1

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 12076, 0.92 per cent; No. 12078, 1.9 per cent.

This soil occupies only a small proportion of the area surveyed. It occurs as local patches, scattered throughout the area, and is found most typically developed on the slopes of some of the gently rolling hills and in some of the level upland areas. It is also found in the local, basinlike depressions of the uplands, and as small, fingerlike patches along the courses of arroyos and minor stream channels.

The type possesses no marked physiographic features. The surface varies considerably, however, from a level plain to gently rolling uplands with basinlike depressions. Along the small streams, on the slopes of the hills, its surface is often cut by many small shallow gullies. In some instances the streams have cut down several feet through the soil, forming deep and narrow channels with perpendicular walls.

With the exception of a few of the local drainage basins, the natural drainage of this soil is good. In some of the lower areas, especially in the basins, the drainage conditions are poor. These places are subject to seepage from the heavily irrigated higher lands, and during a portion of the year may be covered with water.

When properly cultivated, this soil possesses marked water-holding power, so that crops do not suffer greatly during droughts for lack of moisture.

The Colorado adobe is a residual soil, formed by the disintegration and decay of the shale or shaly sandstone upon which it rests. The soil occurring in the lake bottoms or local depressions has been modified by the washing of the finer material from the higher areas of this type and the adjoining soils; the deposition of this sediment over the bottoms of these depressions having probably taken place from intermittent lakes or stagnant water.

The cultivable areas of the Colorado adobe are practically free from injurious quantities of alkali. In the low-lying areas affected by seepage and in some of the local basinlike depressions alkali is sometimes found in quantities varying from 0.20 to 0.60 per cent. In these areas the alkali is generally evenly distributed throughout the first 6 feet of soil. Occasionally the first foot is practically free from alkali, the quantity gradually increasing with depth. The shales from which this soil is derived contain a high percentage of mineral salts, which probably accounts for the increased amounts found in the lower portions of the soil.

Only a small proportion of this soil is at present under cultivation. The greater part is too rolling and hilly to be profitably irrigated, and is used for pasturage. As a type it is well adapted to the production of hay, grains, and such other crops as require a moderately strong soil. On some of the lighter areas potatoes are grown, but it is not considered a good soil for this crop. Under proper management it produces good yields of wheat and oats. Excellent yields of alfalfa are annually secured, and the areas in cultivation are mainly devoted to the production of this crop.

The Colorado sand consists of a coarse to fine sand varying in color from light gray to yellow or reddish brown. This last color is due largely to the presence of fragments of feldspar, which, together with small angular quartz grains, form the chief mineral constituent of the soil. A moderate amount of organic matter also occurs in this soil.

The Colorado sand is generally over 6 feet deep, but is occasionally underlain at a depth of from 3 to 6 feet by a light sandy loam. The type is fairly uniform throughout its occurrence in the area, the irrigated lands being somewhat heavier than the unirrigated.

The soil is easily cultivated, and breaks down readily on being turned up by the plow, forming an excellent surface mulch. The type in general contains a very small percentage of silt and clay, but on some of the loamy phases subject to heavy applications of water it shows a tendency to puddle slightly, and if allowed to dry out rapidly forms small clods.

The following table shows the results of mechanical analyses of typical samples of this soil:

Mechanical analyses of Colorado sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12059	½ mile N. of SE. cor. sec. 22, T. 5 N., R. 66 W.	Gray loose sand, 0 to 24 inches.	0.7	5.5	10.3	45.9	29.3	3.8	4.4
12057	¼ mile N. of SE. cor. sec. 14, T. 5 N., R. 66 W.	Brown fine sand, 0 to 24 inches.	.9	5.4	8.6	44.4	27.3	8.5	4.5
12060	Subsoil of 12059	Brown fine sandy loam, 24 to 72 inches.	.3	2.1	3.0	29.1	32.0	20.7	12.6
12058	Subsoil of 12057	Gray fine sandy loam, 24 to 72 inches.	1.8	6.7	6.2	25.4	19.9	20.3	19.7

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 12058, 26.0 per cent; No. 12060, 2.8 per cent.

The Colorado sand covers only a small proportion of the area. The largest area occurs in the uplands on the south side of the Cache la Poudre River, southwest of Greeley, and there are isolated patches immediately west of this area. Only two comparatively small areas are found north of the river. These occur in the northeast corner of the sheet, bordering the valley of Owl Creek.

The surface of this soil is hilly or rolling. It generally caps the domelike elevations of the plains, sometimes dipping well down into loam. A few small streams have cut small, narrow valleys through the areas of this type. This is particularly noticeable along Sheep Draw.

The physiographic position, together with the loose, porous nature of the soil, affords excellent natural drainage. As in the lighter areas of the Colorado fine sandy loam, the drainage is often excessive, and the land has to be irrigated frequently to produce good crops. It absorbs moisture rapidly, so that very little is lost flowing off the surface. Owing to the heavier subsoil this soil is superior to most sandy soils of the West for retaining moisture, and crops do not, as a rule, suffer greatly during droughts.

This soil has probably originated from two sources. The greater part of the material represents the more resistant particles deposited by ancient débris-bearing streams issuing from the foot slopes of the Rocky Mountains during the formative period of the Great Plains. Since the deposition erosion has progressed rapidly, cutting and washing away this material, until only the present soil remains, capping the higher places. It is also probable that this soil has in part been formed from the weathering in place of the underlying sandstone rocks.

No injurious quantities of alkali occur in this soil. Along Sheep Draw there are slight surface accumulations, but they are of no importance.

Only a small proportion of this land is under cultivation, it being for the most part above the irrigation canals. Considering, however, the loose, porous nature of the soil, it retains moisture well, and generally produces better crops than most soils of similar character in the West. When well supplied with moisture it is well adapted to crops that require a light soil.

The native vegetation of the unirrigated areas consists chiefly of sage, soapweed, Spanish bayonet, and a few of the grasses indigenous to the Great Plains. The irrigated areas are devoted to the production of stone fruits, principally plums, to alfalfa, and on loamy areas to potatoes and wheat. Good yields are generally secured, but it is occasionally necessary to apply organic and mineral fertilizers to secure good returns from crops requiring a stronger soil.

COLORADO LOAM.

The Colorado loam consists of a loam or silty loam with a depth of 6 feet or more, generally very uniform in texture, often extending without variation to bed rock. The prevailing color of the type is yellow, but the color varies from a bluish gray to a light brown. In the lower areas the type contains a relatively higher percentage of silt, organic matter.

The soil, to a depth of from 6 to 12 inches, often possesses marked adobe properties, which at times make it very difficult to distinguish it from the true adobe soils. It becomes quite sticky when wet, and if allowed to dry out quickly, breaks up into the roughly cubical blocks characteristic of adobe soil. It also washes very easily when subjected to stream erosion, often forming arroyos several feet in depth, with perpendicular walls.

There is some variation in this type, and in some places the soil is underlain at a depth varying from 3 to 6 feet by very light sandy loam or sand. In the northwestern portion of the area large gravelly bodies occur. The gravel is found scattered over the surface and through the soil, and consists chiefly of angular fragments of sandstone and shale, varying from a fraction of an inch to 5 or 6 inches in diameter. The proportion of gravel is greatest upon the higher ridges of the type.

The following table shows the mechanical analyses of typical samples of this soil:

Mechanical analyses of Colorado loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12063	¼ mile N. of SE. cor. sec. 32, T. 6 N., R. 6 W.	Light loam, 0 to 36 inches.	0.0	0.2	0.2	5.4	41.2	41.3	11.7
12067	Cen. S. side sec. 12, T. 5 N., R. 69 W.	Loam, 0 to 36 inches......	.2	.6	.7	12.9	25.4	36.9	23.0
12068	SW. cor. sec. 22, T. 8 N., R. 69 W.	Loam, 0 to 36 inches......	1.1	1.3	1.7	11.2	17.5	39.9	27.2
12064	Subsoil of 12063......	Fine sandy loam, 36 to 72 inches.	.0	.1	.2	6.6	49.4	31.8	11.7

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 12063, 6.8 per cent; No. 12064, 7.6 per cent; No. 12067, 7.1 per cent; No. 12068, 6.5 per cent.

In extent the Colorado loam ranks second in the area surveyed. It occurs in large areas of irregular outline, occupying the upland portions of the area in the southwestern and northwestern parts of the sheet. The largest body of this type occurs in the southwestern part of the area, extending about 8 miles north of Loveland and east for a distance of about 12 miles. The northeastern boundary of this area is marked by the bottom lands of the Cache la Poudre River. A small body of the type occurs southwest of Loveland, occupying a portion of the uplands on the opposite side of Thompson Creek.

The second largest body of this soil is found in the northwestern part of the area, extending west from Wellington to the foot slopes of the mountains, and south to a line running roughly parallel to the Cache la Poudre River, about 2 miles north of Fort Collins. Two smaller bodies occur north and east of Wellington.

This type occupies rolling and hilly uplands, with occasional small areas presenting comparatively level surfaces. For the most part the hills are well rounded, rising generally 30 to 80 feet above the adjacent depressions, and sloping gradually toward the river, but occasionally they are broken by outcrops of the underlying sandstone and shales. This is particularly the case in the northwestern part of the sheet, where the western edge of the type is marked by steep precipitous bluffs 30 to 50 feet high.

Near the foothills the surface is dissected by many small streams, which have formed small, narrow valleys, or, in some places where erosion has been greatest, deep arroyos with perpendicular sides. The area is dotted by many natural and artificial lakes and local depressions. A few of the lakes are intermittent, containing water only after prolonged wet periods. The soil of these lake bottoms and local depressions is of much heavier character than the typical Colorado loam, and when occurring in areas large enough has been classed as a distinct type.

With the exception of a relatively small area lying along the natural draws and drainage depressions, the Colorado loam possesses excellent drainage conditions. The greater part of the type is well situated for irrigation, and when once thoroughly wet it possesses marked moisture-retaining properties as well as high capillary power.

The Colorado loam is a residual soil, formed by the disintegration of sedimentary rocks. North of the Cache la Poudre River these rocks consist chiefly of sandstone, which is very fine grained, sometimes presenting the appearance of indurated mud and shales, which weather into a soil having a relatively high silt content. South of this stream the sandstone is of a somewhat coarser grain, and the resulting soil is generally lighter than that occurring north of the river.

Like most of the soils of the area, this type does not, as a rule, contain sufficient alkali in the first 6 feet to impair its agricultural value. Considerable alkali occurs, however, in the lower part of the subsoil, as evidenced by the appearance of crystallized salts on the surface in the draws and local depressions affected by seepage from the heavily irrigated uplands. The amount found in these local areas varies considerably, depending largely upon the position of the water table. It is seldom, however, that the amount occurring in the soil exceeds

0.60 per cent for the first 6 feet. The Colorado loam, as a rule, is very productive, and when well supplied with moisture and properly managed is well suited to a number of different crops. It is in general considered one of the most valuable soils of the Greeley area, and all of it except the unirrigable portions is under cultivation. These latter areas, the largest of which occupies a small part of the uplands about 4 miles northeast of Loveland, north of Loveland and Greeley Canal, are for the most part covered with the native grasses of the plains, and are devoted to grazing.

The irrigable areas are particularly well adapted to orchard and small fruits, alfalfa, wheat, oats, barley, potatoes, corn, and sugar beets. While potatoes do well, it is not considered so valuable a soil for this crop as the Colorado fine sandy loam. Of the fruits, apples and cherries are chiefly grown, although the soil is considered well suited to plums and peaches. Strawberries and raspberries are also grown, and are of excellent quality. The production of fruits is developing into a profitable industry.

When properly supplied with moisture and rightly managed, the yields of other crops are as follows: Wheat, 25 to 30 bushels per acre; oats, 50 to 60 bushels; barley, 30 bushels; corn, 30 to 40 bushels; alfalfa, 3 to 4 tons from three cuttings; sugar beets, 15 tons; and potatoes, about 175 bushels. Most of the corn produced in the area is grown in the vicinity of Loveland. The soil in this locality seems to be particularly well suited to this crop, and considerable land is devoted to its production.

COLORADO GRAVELLY LOAM.

The Colorado gravelly loam consists of a gray to almost black heavy fine sandy loam or loam of a rather fine, silty texture to a depth of 6 feet or more, containing varying amounts of red and white sandstone, granite, and shale fragments. The quantity is greatest near the mountains and diminishes gradually toward the east. The gravel and stone range in size from small fragments to pieces 5 or 6 inches in diameter. In the local depressions and drainage areas it is a heavy silt or clay loam, generally of a much darker color than the higher areas. The soil washes very easily, and in cuts the subsoil is frequently of a very heavy, compact nature, often possessing some of the characteristic properties of an adobe soil. In the southwestern portion of the area, and a few miles northwest of Laporte, a phase occurs where the soil is a red sandy loam extending as a rule with but little variation to bed rock.

The following table shows the result of mechanical analysis of a sample of this soil:

Mechanical analysis of Colorado gravelly loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
12068	SE. cor. sec. 4, T. 7 N., R. 69 W.	Gravelly loam, 0 to 24 inches.	1.7	3.2	2.2	15.6	16.4	51.0	10.0

The Colorado gravelly loam occupies only a small proportion of the area surveyed. It embraces a small strip of territory from one-half mile to about 4 miles wide, bordering the entire western edge of the sheet. It includes all of the foot slopes of the Rocky Mountains occurring within the area, and is almost all above the irrigation systems.

The topographic features of this soil consist of hills and ridges cut at right angles by many small intermittent streams that flow down from the mountains into the plains. The surface rises gradually from the eastern to the western boundary of the type. Here the surface is very irregular, consisting of the high hills and ridges characteristic of the foot slopes of the Rocky Mountains.

The Colorado gravelly loam has excellent natural drainage. The surface is so rolling and hilly that only a very small part of the rainfall is absorbed by the soil, while the many small stream channels furnish excellent outlets for the drainage waters. A little alkali occurs in the soil along some of these streams and draws, but in general the soil is free from injurious quantities of salt.

The Colorado gravelly loam is distinctly a colluvial soil formed from weathered rock débris brought down from the mountain immediately west of the area by mountain torrents, and during the process of disintegration and decay this material has been further modified by stream action.

The irrigable portion of this type is well adapted to fruits, particularly apples, and to wheat, oats, barley, alfalfa, and sugar beets. When well supplied with moisture the yields compare favorably with those obtained on the Colorado fine sandy loam. It frequently happens, however, that owing to the difficulty with which some of these lands are irrigated, the crops are not sufficiently supplied with moisture, and in cases of this kind the yields fall considerably below the average.

scanty growth of weeds and a few of the native grasses. During wet seasons the grasses grow rapidly and the lands are devoted to grazing.

BILLINGS LOAM.

The Billings loam, like the Laurel sandy loam, varies widely in texture. In general, it consists of a loam, usually from 2 to 5 feet deep, and underlain by a gritty or gravelly loam, or in some instances by sand or sandy loam. The texture, however, ranges from a heavy sandy loam to a heavy clay loam, which gradually becomes heavier with depth until the subsoil is reached. Each of these variations occurs in such limited areas and is so intermingled with the others as to make a separate classification impossible.

The color of the soil varies from a reddish brown to a dark gray, and in some instances, owing to an increased amount of organic matter in the soil, is almost black. The subsoil is generally of a much lighter color. A small amount of fine gravel is occasionally found scattered over the surface and through the soil, but the proportion is not high enough to affect the cultivation of the crops.

This soil occurs as small, narrow strips, the maximum width rarely exceeding one-half mile, bordering the streams that flow across the Colorado fine sandy loam. The type is found only north of the river in that part of the Colorado fine sandy loam which lies northwest of Greeley. Nearer the streams the surface is generally level, though sometimes cut by old channels or small swampy areas. Farther back the land usually rises quite abruptly, forming the sloping walls of the small valleys. The outer part of the strip is fairly well drained, but near the streams the drainage is naturally poor. In the bends of the canals and in areas most affected by seepage, water is at or near the surface throughout the season. Most of this seepage, however, is carried off by the streams which the type borders, while the underlying stratum of sand and gravel also furnishes outlet for the surplus water. The cultivable areas rarely require irrigation, the crops being supplied with moisture from seepage.

The Billings loam owes its origin mainly to the material washed down from the surrounding uplands, the heavier phases of this type having been formed from the accumulation of the finer and more loamy material in the depressions and low-lying areas. In addition to local wash a small proportion of the material composing the soil has undoubtedly been transported to its present position from some distance to the north by the streams which it borders. The sandy and gravelly subsoil has been derived largely from the same source.

In the seepage areas of this type alkali occurs in varying amounts, but rarely exceeds 0.60 per cent for the 6-foot profile. The greatest amount is generally found in the upper portion of the soil, the subsoil being practically free from injurious amounts. Slight surface accumulations occur, but the amount is small and seldom sufficient to injure plants. The worst areas are found, as a rule, in the bends of the canals. Seepage in these places is generally great, and the alkali occurs in relatively large amounts on the surface and through the soil. The first and second feet are generally the most highly impregnated. This, however, depends largely on the position of the underground water.

This type in general is a somewhat stronger soil than the Colorado fine sandy loam. The cultivable areas are adapted to about the same kind of crops as the Colorado fine sandy loam, with the possible exception of potatoes, and all crops can be grown without irrigation. The soil is generally too wet for potatoes, and the tubers often rot, while the plants are very susceptible to blight. The soil is especially well adapted to sugar beets, and the yields and percentages of sugar content compare favorably with those secured on the soils of the river bottoms. During favorable seasons the average yields of crops secured on this soil are about the same as those obtained from the Colorado fine sandy loam. The wet, swampy areas are covered for the most part by some of the swamp and salt grasses, which are used either for pasture or hay.

FORT COLLINS LOAM.

The Fort Collins loam consists of a reddish to very dark brown light loam from 4 inches to 1 foot in depth, underlain by a layer of heavy loam from 1 to 4 feet in thickness. Beneath this layer of loam the subsoil grades again into a light loam, similar in character to the soil, and extending to a depth of 6 feet or more. The soil becomes very sticky when wet, and bakes badly, often breaking into rough cubical blocks like adobe soils upon exposure after puddling.

In the areas occurring in the extreme eastern portion of the sheet, north of the South Platte River, there is a phase varying somewhat from the typical soil. Here the soil consists of a heavy loam, generally extending to a depth of 6 feet or more without any noticeable change in texture.

The table following shows the results of mechanical analyses of typical samples of this soil.

Mechanical analyses of Fort Collins loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12069	2 miles SE. of Lucerne.	Loam, 0 to 36 inches	1.0	2.4	2.0	13.9	28.9	32.9	19.0
12071	¼ mile E. of SW. cor. sec. 27, T. 18 N., R. 69 W.	Sandy loam to loam, 0 to 36 inches.	.8	3.4	5.2	20.8	17.0	30.1	22.7

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 12069, 5.2 per cent; No. 12071, 1.2 per cent.

The Fort Collins loam covers a relatively small area. It occurs most typically developed in two areas near Fort Collins, the larger extending southeast from that town to the Fossil Creek Reservoir and the smaller lying east of Fort Collins across the river. A few other areas occur as isolated patches in the northwestern part of the survey. Four comparatively large areas are found in the southeastern part of the sheet. The largest of these occurs in the great bend of the South Platte River, while the second in size extends southeast from the town of Eaton to the river bottoms.

The surface of this soil is practically level, though some areas are slightly rolling or undulating. The surface is unmarked by rock outcrops, bluffs, or prominent terrace lines, but is sometimes pitted by erosion and occasionally cut by small, intermittent stream channels. There are a number of natural and artificial lakes and a few basinlike depressions. The latter often contain a much heavier type of soil, and during a portion of the year the bottoms are covered with water.

The Fort Collins loam is for the most part a residual soil, formed by the weathering in place of clayey sandstones and sandy shales. It is quite probable, however, that a small proportion of the material composing this soil has been derived from the ancient débris of the mountain slopes that formerly covered this territory. The material thus deposited was probably much lighter than at present and devoid of large gravel, and has since weathered into the loam.

Most of this soil is well drained. In the eastern part of the area, however, the drainage conditions are rather poor, often necessitating the use of artificial drains to produce good crops. The type here is quite badly affected by seepage from the canal, and the water table is sometimes found within 2 to 4 feet of the surface. Owing to its heavy texture, the soil absorbs moisture rather slowly, so that a large percentage of the rainfall is lost by surface drainage. When once thoroughly irrigated it retains moisture well and is able to withstand drought better than most of the soils of the area.

Only limited areas of the Fort Collins loam affected by seepage contain sufficient quantities of alkali to injure crops. In some of the sloughs and local depressions from 0.20 to 0.60 per cent of alkali is found. In section 4, T. 5 N., R. 64 W., occurs the worst affected area, the soil containing over 1 per cent for the first 6 feet, with about 2 per cent occurring in the third foot. Below this the alkali diminishes in amount, the sixth foot containing about 0.80 per cent. Many surface accumulations are found in the area occupied by this soil, but the amount is generally so small as to be entirely negligible.

The Fort Collins loam is, when properly managed, not difficult to cultivate, and is well adapted to the growing of all crops suited to the climate. It is a moderately strong soil, and is considered one of the most fertile and valuable soils of the area. The principal crops grown, and those to which the type is best adapted, are the fruits, chiefly apples, wheat, oats, barley, potatoes, alfalfa, and sugar beets. In the vicinity of Fort Collins this is considered the best apple soil of the area, and there are many small tracts devoted to this crop. The fruit produced is of excellent quality and the yields are generally very large. Alfalfa is grown on this soil for hay alone, none of it being pastured. It yields from 3 to 4 tons from the three cuttings usually secured in a season. The soil is in general too heavy for potatoes, except on a sandy phase east of Lucerne, which produces some of the finest potatoes in the area, yielding from 150 to over 300 bushels per acre. Sugar beets average about 15 tons per acre, while the average yields of the grains compare favorably with those secured on the Colorado loam.

BILLINGS SILT LOAM.

The Billings silt loam is a grayish to dark-brown, silty, easily cultivated loam from 18 inches to 3 feet deep, underlain by a sandy loam, or loam which is in turn underlain by gravel. When wet the soil has quite a sticky feel and tends to compact in the roads. Upon drying it cracks, somewhat in the nature of adobe soils. In some places small gravel strew the surface, brought up from the gravel strata below by prairie dogs.

This soil is found principally along Boxelder Creek near the town of Wellington. Only small areas were found. It has a smooth, apparently level surface, and requires little or no smoothing to prepare it for irrigation.

Very little irrigation has taken place as yet in the section where this soil is found; hence it is yet well drained and free from alkali salts. Extensive irrigation upon the highlands might result in its affected, but drainage could be installed with little difficulty with Boxelder Creek as an outlet.

The soil is of alluvial origin, having been deposited from the waters of Boxelder Creek during past overflow or rainy seasons when this creek covered much of the bottom lands.

This silt loam soil is especially adapted to the growing of sugar beets. Grains and alfalfa also do well, but the best paying crop grown is the sugar beet. The average yields of these crops are as follows: Wheat, 30 to 40 bushels per acre; sugar beets, 15 tons; and alfalfa, about 4 tons in a season of three cuttings.

The following mechanical analysis shows the texture of this soil:

Mechanical analysis of Billings silt loam.

No.	Locality.	Description	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12061	SE. cor. sec. 28, T. 9 N., R. 69 W.	Clay loam, 0 to 26 inches.	0.0	0.1	0.4	5.6	7.5	53.0	33.3

The above sample contained 6.4 per cent of calcium carbonate ($CaCO_3$).

UNDERGROUND AND SEEPAGE WATERS.

At the beginning of irrigation in the area mapped the general level of the water table was very different from the level to-day, having materially risen since water was applied in a general way. As early as 1896 Professor Carpenter found that 30 per cent of the water diverted and applied in irrigation again found the river bed as seepage. The value of this water at prices then obtaining was $300,000 to $500,000. Owing to increased irrigation and the greatly enhanced value of irrigation water, both the quantity and value of this seepage must now be greatly increased.

Many of the low lands in the smaller valleys and along the rivers have become virtually swamped by the excess of seepage. Deep drainage of these lands should not only so reclaim them that profitable crops may again be grown, but would develop a large quantity of water to be used in irrigation.

Many pumping plants have been installed in these low lands to supply water for irrigation and have been almost universally successful. Several deep wells have been bored in the valley to develop artesian water. Wells that flow a small amount of water have been obtained, but the supply from this source is practically negligible.

WATER SUPPLY FOR IRRIGATION.

Practically all the cultivated land of the Greeley area is irrigated. This irrigation is mainly by gravity ditches drawing water from Cache la Poudre and South Platte rivers, Big Thompson Creek, and a number of other small creeks that flow across the area. Quite a number of wells have been sunk in the water-bearing gravels along the rivers and creeks, which in the aggregate furnish water for a considerable acreage. The main source of supply, however, is that from Cache la Poudre River and Big Thompson Creek. Many reservoirs and lakes have been constructed to impound flood waters for use in late summer, these forming a valuable regulation of the regular run-off. Practically the whole supply of flood and normal run-off waters is thus utilized. The area of irrigable land is far in excess of the supply of water, so that these reservoirs instead of adding to the total acreage of irrigated lands, simply assure a more permanent and adequate supply for the lands already covered by ditches.

All the water used is of good quality, coming principally from the high mountains on the west. The well and drainage water is also of good quality, no harm following its use.

The subject of water supply and irrigation in this region is discussed at length in No. 9 of the Water-Supply and Irrigation Papers of the United States Geological Survey by David Boyd. This paper covers nearly every phase of the subject, and gives a much more detailed discussion than is possible in the limited scope of this report.

Probably the greatest development possible in this area lies in the sinking of wells and the installation of pumping plants. Practically all of the low lands of the area have a very high water table, making irrigation by pumping very economical. The price of water rights under the older ditches has advanced until the interest on the original investment and the water rental often exceed the cost of installation and maintenance of pumping plants.

ALKALI IN SOILS.

Alkali is quite generally found in the small swales and valleys of the area, in the nonoverflow part of the river bottoms, and often along canals and reservoirs. The areas are usually but a few acres in extent, although in the aggregate the extent is considerable. Trouble from alkali in all cases is here preceded and accompanied by trouble from excessive ground water. Examinations show that many areas that appear to be badly alkaline in fact do not have harmful accumulations, but damage to crops is almost wholly due to water-logging.

With the rainfall that the area receives it may be safely said that if seepage water were disposed of the alkali areas would disappear.

Directly, the alkali comes from the evaporation of seepage water from the surface of the soil. The salts are taken up by the water as it percolates through the soil, and may come from an accumulation already in the soils or from chemical reactions due to the weathering of the soils. Irrigation water, or water in the streams where they emerge from the mountains, is practically pure, the amount of salts contained being negligible.

Several samples of the alkali salts, as found efflorescing on the surface, and samples of the alkali soils, were analyzed in the laboratory of the Bureau. Mr. Headden, of the Colorado Agricultural Experiment Station, in Bulletins Nos. 46, 58, 65, and 72, has discussed the subject of alkali in the soil. David Boyd, in the History of the Union Colony, has also discussed the subject.

The following table gives the results of analyses made by this Bureau:

Chemical analyses of alkali crusts.

Constituent.	715a	716a	717a
	1 mile W. of Lucerne, alkali crust 0 to ¼ inch.	4 miles E., 1 mile N. of Lucerne, alkali crust 0 to ¼ inch.	2 miles S. of Trinvalt, alkali crust 0 to ¼ inch.
Ions:	*Per cent.*	*Per cent.*	*Per cent.*
Calcium (Ca)	3.61	3.89	2.47
Magnesium (Mg)	7.98	10.57	8.54
Sodium (Na)	15.36	10.75	15.28
Potassium (K)	1.66	.65	1.71
Sulphuric acid (SO_4)	65.06	72.75	65.75
Chlorine (Cl)	6.48	1.30	6.17
Conventional combinations:			
Calcium sulphate ($CaSO_4$)	12.05	13.16	8.54
Magnesium sulphate ($MgSO_4$)	39.31	52.55	42.50
Potassium chloride (KCl)	3.01	1.20	3.42
Sodium sulphate (Na_2SO_4)	36.90	31.88	38.14
Sodium chloride (NaCl)	8.43	1.11	7.40
Per cent soluble	6.64	10.79	10.54

These analyses bear out the findings of the earlier investigators, viz, that the salts are mainly sodium and magnesium sulphates. Gypsum is also present in quantities, but this salt is difficultly soluble, as well as harmless, and it should not be considered as a part of the alkali.

It has been stated that the accumulations of alkali are due to evaporation of seepage waters from the surface in poorly drained or seepage areas. Wherever there is alkali, water is found close to the surface. This water has only small amounts of salts, so that the part of the soil below the water table has no harmful accumulation. Therefore the alkali is strictly a surface accumulation. In some instances rainfall or irrigation has washed a part of the alkali down into the second or third foot of soil, but there are no deep-seated accumulations. The surface condition always represents the maximum of the evil.

RECLAMATION OF ALKALI LANDS.

Already many acres of lands that a few years ago were considered too alkaline to grow crops have been reclaimed and now are highly productive.

Headden, in the beginning of Bulletin 72, already cited, says: "I am convinced that the only question of alkali that we have resolves itself into one of drainage, and beyond this there is no alkali question for us." Because of the semiarid nature of the region this is probably a true interpretation of the problem. If the soils now alkaline be drained, deeply plowed, and carefully cultivated, such accumulations of alkali as now exist will no doubt disappear in the course of time. There can be no question, however, that the smoothing and heavy flooding of the lands affected, after drainage, would accomplish the desired purpose much sooner. Whether or not this flooding is a desirable thing will depend on the availability of water for the purpose and the degree of alkalinity of the area to be treated. If the lands are not so bad as to preclude the growth of sugar beets the feasibility of flooding to reclaim is doubtful. The greater part of the swamp and alkali lands if drained, plowed deep, and cultivated carefully, would produce immediately a paying crop of beets. If, however, beets will not grow, sorghum or barley should be sown and flooded.

On the whole, the alkali problem, as compared with that of strictly arid regions, is not a difficult one, and the aggregate of lands so affected is much less than in most irrigated regions of the arid West.

AGRICULTURAL METHODS.

On most of the farms in this district a rotation of crops has been devised that tends to preserve the fertility of the soil and obviate the necessity of artificial fertilization. Before the advent of the sugar factories potatoes, grain, and alfalfa were the crops principally grown upon the high lands in the eastern part of the area and on the best-drained bottom lands, while on the lower bottoms many vegetables were produced. The wetter parts of the bottoms were given chiefly to the growing of native grasses for hay and pasture. In the western part of the area the prevailing soils are heavier and have never been considered good for potatoes. Many apple and plum orchards have been successful. Prior to the introduction of the sugar beet the field crops were almost wholly grain and alfalfa. Sugar beets have not yet a well-defined place in the rotation, but are grown or not grown in a rather hit and miss way.

Any intelligent crop rotation for this region must take cognizance of the kind or type of soil, the topography or surface grade, and the state of drainage. These things have of necessity been somewhat recognized in actual farm practice, but are not so well recognized as controlling factors in the crop rotation as they should be.

There are several more or less distinct crop rotations practiced by the best farmers on the various soils and in the various districts of the area. On the slightly rolling sandy loam uplands near Greeley and Eaton, grain one year, alfalfa sown with it and harvested for two years after, then potatoes two years, and back to grain and alfalfa again, is the rotation most in vogue. A few farmers are supplanting the last year of potatoes by a beet crop, or growing beets for the two years. The advisability of growing beets on these lands instead of potatoes is a much mooted question. Beets are more difficult to irrigate and require a greater amount of water for their maturity. For these reasons it is most difficult to grow beets on lands that have a steep slope, so that different fields having the same soil type may differ greatly in their suitability for these two crops. In general, the lands having steep slopes are more suitable for potatoes than for beets, and if the slopes become too pronounced neither is profitable. The lands of steep slopes are generally given over exclusively to grain and alfalfa, and these crops are doubtless more valuable for such lands than those just mentioned or any others requiring intertillage. In the western part of the area there is a great deal of the sandy-loam soil, but potatoes have never been grown extensively west of New Windsor, so that when sugar beets were introduced all the lands sufficiently level to permit proper irrigation were devoted more readily to this crop than to potatoes. The rotation for these lands is wheat one year, with alfalfa sown with the wheat and harvested for two years thereafter; then sugar beets for two years, and back again to grain and alfalfa. The many apple, plum, and cherry orchards and the berry lands of course have no rotation.

On the bottom lands along the larger streams and small creeks the following rotations are practiced: Grain one year, alfalfa two years, and potatoes two years for the best-drained parts; grain one year, alfalfa two years, and sugar beets two years for the poorly drained; and native grasses for the swamped areas. As stated, garden and truck crops are quite extensively grown in parts of the river bottoms, but no rotation is practiced, applications of barnyard manure being relied upon to keep up the productiveness of the soils.

returns from the land and at the same time prevent deterioration of the soil. Nitrogen is the element of plant food most often deficient in the soil, and also the most expensive to purchase in fertilizers. Alfalfa is a leguminous or nitrogen-gathering plant, hence its presence in each rotation noted above. Since the introduction of alfalfa in the eighties, practically all the soils have, by consistently using this crop in rotation, been brought to as high a state of productiveness as they were in the early seventies when farming began. Alfalfa as a money crop does not give the returns that sugar beets or potatoes do, so that as cultivation becomes more intense the aim of the farmers should be to reduce to a minimum the leguminous crop, and increase, so far as the soil will stand it, the money crops. Moreover, alfalfa has such a heavy root system that it is quite difficult to break up the fields for other crops. If some other legume equally as valuable as alfalfa, but less difficult to handle, could take its place, this would be a great advance. In the southern part of the State, in the San Luis Valley, field peas are grown very successfully, and are very valuable as a fattening feed for lambs or hogs. If these field peas were introduced here to supersede the alfalfa on the beet and potato lands, these crops could no doubt be alternated with peas, and the income from a given acreage greatly increased. Wheat may be grown under so many different conditions of nonirrigation that its price is usually so low as hardly to furnish a profit on these high-priced lands, and it must eventually be dropped from the rotation, except on the lands too rough to grow potatoes or beets.

As indicated, potatoes are quite generally planted in the rotation to follow alfalfa. The land is spring plowed from 6 to 10 inches deep and thoroughly harrowed. Planting is done with a horse planter, one row at a time, with an interval between the rows of about 3½ feet, and the hills from 11 to 23 inches apart. The time of planting is from the middle of May to the middle of June, so that the forming of the tubers will take place after the hottest of the weather. After planting a ridge is thrown up over the row of planted seed with a cultivator, and the whole field harrowed to kill early weeds. The rainfall is usually sufficient in the early season, and irrigation is rarely practiced before a healthy growth of vines is made and a good root system established. After the potatoes come up they are cultivated twice, the last cultivation leaving the row ridged to a height of 6 or 8 inches. The crop is then "laid by," except for the irrigation that is so necessary for the production of the large tubers for which the region is so justly famed. A furrower is run through the field in each space between the rows, and about August the first irrigation is begun. The object in irrigation is to maintain a uniform high a moisture content is injurious to the tubers. It is to prevent too copious wettings that the deep furrows are made. The amount of irrigation necessary or the number of applications of water is dependent upon the kind and slope of the soil. Steeply sloping fields require more frequent irrigations than the more level ones, and the very leachy soils dry out more quickly than the heavier ones. From two to four irrigations in the month of August and early part of September are necessary to mature the crop. A few potatoes for the early market are dug during the latter part of September, but the main crop is dug principally during October.

Digging potatoes has been reduced to a science and is largely done by horse machinery. A digger drawn by four horses and requiring only one man as driver digs and leaves exposed the potatoes of one row at a time. In an ordinary day's work this machine will cover 5 acres. A sorter and sacker is next drawn through the field, the potatoes being picked up and placed in a sort of hopper, from which they are sorted, the small ones being run into a separate sack. To pick up, sort, and sack the potatoes, and then sew the sacks for a digger requires the services of ten to twelve men, according to the yield per acre.

At all the railway stations there are immense warehouses and cellars where potatoes are stored, and nearly all farmers have one or more large cellars on the farm that also give storage room. Many potatoes are shipped as soon as dug. Those which are put in storage are disposed of as the market demands or the needs of the owner require.

While upon the best-managed ranches sugar beets have found a place in the rotation, and the injurious effects of continuous cropping to this exhaustive crop are well understood, a few have planted beets upon the same land for four or more years, and some are advocating such practices as being in no wise detrimental to the soil. On such soils it is important that other crops be grown in rotation if the productiveness is to be long maintained. The necessity for rotation has so often been demonstrated that it seems unnecessary to enter into a discussion of the matter here, other than to sound a note of warning to the oversanguine, who, because sugar beets are profitable, are rapidly impoverishing their soil for the larger immediate return that comes from growing only this crop.

Sugar beets are sown with a large beet drill resembling a wheat drill, in rows 18 inches apart. Deep spring plowing and thorough cultivation prepare the seed bed. Sowing takes place from May 10 to about June 10. It requires 18 to 20 pounds of seed to the acre. The seed is drilled quite thick in the row, and after reaching such a size as to insure continued thrift the beets are thinned to one in a place 9 to 12 inches apart.

During their growth the beets are hoed twice, cultivated twice, and irrigated sufficiently to keep the soil in a favorable moisture condition. Irrigation is by the furrow method, furrows being made in the alternate spaces between rows. Harvesting begins from the 15th to the 25th of October, and is usually finished by December 1. All the hand work is, as a rule, done by contract, Russian families taking the contracts at from $20 to $22 an acre. The team work is done by the farmers themselves. During the season of 1904 beets were bought at a flat price of $5 a ton delivered at the factories or at one of the many beet dumps along the railroads of the valley. Switches with these receiving stations occur at intervals of about 2 miles along all the railroads.

Alfalfa is usually sown with spring wheat. It is rarely pastured, being cut almost exclusively for hay. Occasionally a crop is allowed to mature for seed. Three cuttings per season are obtained, which yield from 3 to 5 tons per acre. The hay is used for feeding stock upon the farm, and, along with grain shipped from the corn-growing regions, for fattening sheep taken from the surrounding ranges. The rainfall is insufficient to injure the stacks, so the crop is stacked and left in the field until such a time as it is needed.

Irrigation for alfalfa is by flooding from small ditches run along the highest parts of the fields, from which the water is caused to spread out by putting in small dams just below the part of the field it is desired to flood. In this way very rolling fields are successfully flooded and produce good crops.

Oats and wheat are the two grains principally grown. They are both sown in the spring. If following potatoes or beets the ground is often not plowed, but simply broken up by a disk harrow and the seed sown. These grain crops are flooded in the same way as the alfalfa fields. After irrigation ceases the small furrows are plowed in so that harvesting machinery may cross them.

Self-binders are used in harvesting, the bundles being placed together in small cocks in the field. Much thrashing takes place in the field soon after cutting, but all the grain can not be handled immediately, and many fields are stacked and thrashed later as the machines make their rounds. Often it is the first of November before the entire crop has been thrashed.

The orchards of the area are plum, apple, and cherry. Seldom are the trees cultivated after coming into bearing, but they receive irrigation from small furrows and are usually sown to alfalfa. While the trees are yet young garden crops, corn, potatoes, or sugar beets are grown in the spaces between the rows. Irrigation and cultivation of these crops furnish sufficient moisture and tillage for the trees.

Doubtless better success would be had with the bearing orchards if cultivation continued, as much moisture is lost from evaporation from the uncultivated surface, and in times of scarcity of water the trees often suffer from lack of moisture.

During the last few years raspberries have become quite an important crop in the vicinity of Loveland. These are planted in rows 6 to 8 feet apart each way, and cultivated and irrigated as are the other hoed crops of the area. The winters are too severe for the vines if left uncovered, so each fall, in the latter part of October or the first of November, the vines are bent down along the row and covered to the depth of a foot or more with earth. This protects them from freezing, and in the spring, upon being uncovered, they show no ill effects from their winter's burial.

AGRICULTURAL CONDITIONS.

Generally speaking, the farming class of this area is very prosperous. Land values, owing to the introduction of the beet crop, have practically doubled in the last five years, and the crops now grown pay a good interest on this new valuation, besides giving a fair remuneration for the labor expended in their production.

The experience of recent years has demonstrated that much of the sandy loam in the western part of the area is well adapted to the growth of potatoes, so that as the growing of this crop is extended and sugar beets more and more take the place of the grain crop on the heavier soils, land values may be expected to advance still further.

Many farmers own the farms they cultivate, but large acreages are owned by capitalists who rent the land to the farmers in 80 to 320 acre tracts. A part of the crop is given as rental to the owner.

The largest estate in the valley is composed of the lands obtained by B. H. Eaton in the early history of irrigation in the valley. At present the size of the farms given to general farming ranges from 80 to 320 acres, the average size being 160 acres. The acreage in individual holdings, however, will of necessity soon be reduced for all lands suited to the growth of sugar beets or potatoes. A 40-acre farm of such lands will produce sufficient revenue for the maintenance of an ordinary family, and as development advances this will likely be the standard size of the farm. Those lands which, because of topographic features, are, at the present stage of development, only suited to the growing of grain and alfalfa, can easily be handled in 160-acre tracts, and as these crops do not require so much labor or bring in such large returns as the potato or beet crops, the farms should be larger.

Practically all the hand labor necessary in the care and harvesting of the potato and beet crops is done by contract. In the beet industry many Russian families have found employment. As already stated, they usually contract to do the hand work for $20 to $22 an acre. Every member of the family over 7 years old is counted as a field hand, and contracts are taken on a basis of 7 acres per person. This class of labor is very satisfactory, and requires little overseeing on the part of the farmers. A more equitable system would be one based on tonnage for at least the tapping, as under the present system there is no incentive to the laborers to increase the tonnage. Under the present system it costs from $40 to $45 an acre to grow and market a crop of beets. As the beets bring $5 a ton at the factory or receiving stations along the railroads, all receipts over 9 tons per acre are profit. If only the lands suited to beets be planted and an intelligent system of rotation be followed, an average of 15 tons per acre should be obtained, thus yielding a profit of $30 an acre.

Farm laborers hired to do the team work are usually from the older farming sections of the middle West. They are a good class of laborers, and expect to become landowners or renters themselves. To get skilled irrigators is quite a problem. Whenever Mexicans can be obtained their services are satisfactory and much sought after.

The principal hand work necessary for the potato crop is in picking up and sacking the tubers. This is usually done by contract, the price ranging from 5 to 8 cents a sack. Nomadic whites are usually employed, and are not so satisfactory as the laborers procured by contract to do the beet work. As the potato picking lasts but a short time, however, and a great number of men are then needed, it is difficult to see how this condition can be bettered.

Farmhouses are of all kinds and sizes, but not infrequently are substantial structures of brick. The older settlers, who own their farms, have excellent houses and outbuildings.

Country school buildings are principally of brick, the few old frame structures being rapidly replaced by modern ones of brick.

All of the products of the valley are of good quality. "Greeley potatoes" have a reputation throughout the United States, and are justly celebrated. Large, uniform in size, and of excellent quality, they find a ready market wherever potatoes are needed.

Sugar beets grow extremely well, and have a fair average percentage of sugar. Alfalfa fields are as good as in any place the writer has seen in the United States, and produce hay of an excellent quality. Such fruits and vegetables as are grown are of good quality and flavor. Wheat and oats are of fair average quality. Occasionally rust attacks the wheat, as was the case in 1904. This greatly reduces the yield and lowers the grade. In only two years since the settlement of the country has this rust been general.

from Denver to Cheyenne; the Colorado and Southern from Denver to Fort Collins and Wellington; and a branch of the Colorado and Southern, which connects Greeley and Fort Collins. These lines furnish ready railroad communication to all parts of the valley.

Greeley, Fort Collins, and Loveland are the principal towns of the valley, and furnish quite a home market for fruits and vegetables. At Greeley, which is a town of 5,000 or 6,000 inhabitants and the county seat of Weld County, is situated the State Normal School. Fort Collins, the county seat of Larimer County, is about the same size, and is the site of the State Agricultural College.

As stated in the history of agricultural development, Greeley, Fort Collins, New Windsor, Eaton, and Loveland all have beet-sugar factories, as well as flour mills, which consume a great deal of the wheat of the area. Much of the wheat, fruit, vegetable, and potato crops is shipped to outside markets, the mining towns of the State taking large quantities and paying good prices for all these products.

SOIL SURVEY OF THE BEAR RIVER AREA, UTAH.

By CHARLES A. JENSEN and A. T. STRAHORN.

LOCATION AND BOUNDARIES OF THE AREA.

The Bear River area lies in Bear River Valley, in the north-central part of the State of Utah, and the city of Brigham, about 8 miles north of the southern boundary of the area surveyed, lies in north latitude 41° 30′ and west longitude 112°. The parallel of 42° north latitude forms the northern boundary of the State. The area surveyed extends north and south from T. 8 N. to T. 12 N., inclusive, a distance of 30 miles, varies in width from 6 to 15 miles, and comprises 213,632 acres, or about 334 square miles. This includes practically all the irrigable land in the valley within the State and also part of the former bed of Great Salt Lake.

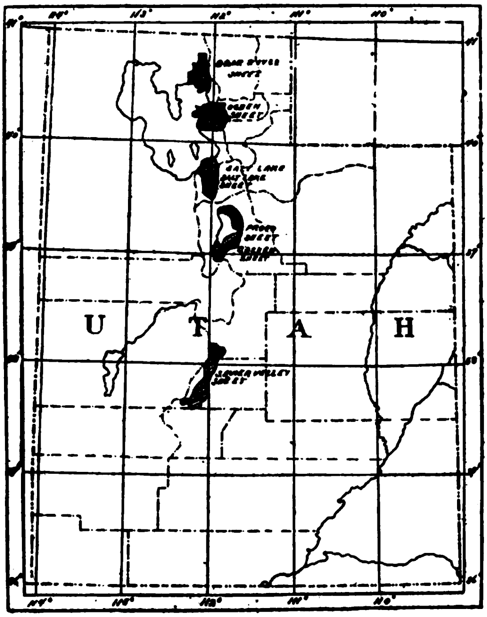

FIG. 41.—Sketch map showing location of the Bear River area, Utah.

About 20 square miles in the extreme northern part of the State, part of it irrigable, was not included in the survey.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The area surveyed was settled about 1850, the first settlement in the State having been made at Salt Lake City in 1847 by Brigham Young and his followers. For a number of years settlements were confined to the eastern side of the valley, comprising in order from south to north the towns of Willard, Brigham, Honeyville, Deweyville, and Collinston. The last-named town was settled later than the others.

During the completion of the Central Pacific Railroad, now the Southern Pacific, in 1868–69, other settlements were established, the principal one being Corinne. This town was for some time an important freighting terminus for points in Idaho and Montana, until the Utah and Northern Railroad, now the Oregon Short Line, was built north into those States.

The only source of population for a number of years was the immigration of members of the Mormon Church from eastern States, and, at a later date, from foreign countries. With the advent of the railroads the Gentiles began to populate the State, especially the mining regions. In a short time outside capital began to be invested in many enterprises.

Agricultural development in a country with a small amount of precipitation necessarily depends on the development of irrigation systems. Before these are established stock raising and mining constitute the principal industries, and both of these are at present of great importance in the State of Utah.

Irrigation in the area surveyed was first practiced in and around Brigham, Boxelder Creek and other smaller mountain streams being diverted for this purpose. No elaborate canal system was built, and each person helped himself to what water he wanted or needed, building private ditches for this purpose. A well-regulated system is now in force, dividing these streams among the irrigators.

The first elaborate and most important irrigation system in the area was the Bear River canal, which was built during the late eighties and early nineties, but not entirely completed until some years later. This system was at first confined to the area west of Bear River, but during 1903–4 a branch, known as the East Side Canal, was built on the east side of that river, and was first used in 1904.

Before the Bear River Canal was built considerable dry farming was carried on, but this has since been practically abandoned in favor of the safer method of irrigation.

For a more complete history of irrigation in Utah, the reader is referred to other publications of the Bureau of Soils.[a]

CLIMATE.

The climate of the valley is semiarid. The normal annual rainfall at Corinne, in the central part of the area, is 11.62 inches, and the relative humidity is low. From June to October, inclusive, the season when crops require the greater part of the moisture necessary to their growth, the rainfall is but 2.99 inches. There is an abundance of sunshine, especially during summer, and the wind movement is seldom high enough to cause damage.

The normal annual temperature is 51.3° F. at Corinne; the highest monthly normal is 80°, in July, and the lowest is 24°, in January. The summer days often become quite warm, but owing to the low humidity the heat is not oppressive, and usually the nights are cool.

Severe electric storms often visit the valley, but the damage done by these is unimportant.

Spring frosts are seldom of much consequence, but the fall frosts sometimes nip the fruit, though without much resultant injury. The average date of the last killing frost in spring is about May 15, and of the first in fall about October 7.

Normal monthly and annual temperature and precipitation.

Month.	Corinne.		Ogden.		Logan.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	° F.	*Inches.*	*° F.*	*Inches.*	*° F.*	*Inches.*
January	24.7	1.27	28.5	1.49	24.2	1.09
February	30.1	1.25	33.0	1.56	25.7	1.16
March	39.9	1.26	41.1	1.59	33.8	1.83
April	50.5	1.10	52.6	1.42	46.7	1.80
May	61.2	1.18	61.8	1.61	55.2	2.21
June	71.4	.50	72.0	.57	63.4	.64
July	79.6	.47	79.4	.25	71.0	.40
August	74.4	.43	76.7	.47	70.5	.51
September	65.6	.64	65.7	.68	61.1	1.09
October	51.5	.95	51.8	1.33	50.2	1.15
November	37.8	1.03	39.3	1.21	37.9	1.14
December	29.0	1.54	31.7	1.65	25.8	1.08
Year	51.3	11.62	52.8	13.83	47.1	14.10

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[a] A Soil Survey in Salt Lake Valley, Utah, by Gardner and Stewart, in Field Operations of the Division of Soils, 1899; Soil Survey in Weber County, Utah, by Gardner and Jensen, in Field Operations of the Division of Soils, 1900; Soil Survey in Sevier Valley, Utah, by Gardner and Jensen, in Field Operations of the Division of Soils, 1900.

PHYSIOGRAPHY AND GEOLOGY.

Physiographically, the valley may be divided into three sections: The cultivated mountain slopes on the east and west sides of the valley; the low-lying, flat bottom lands, which formerly were covered by Great Salt Lake in its concentrated condition, and the higher lying and level prairie lands, north of the lake bottom lands, and included between the mountains.

The cultivated mountain slopes are not steep, and vary from a quarter of a mile to 1 mile in width on the east side, while their width is less on the west side of the valley. There are no rolling foothills between the mountains and the valley, but the mountains rise abruptly from the slopes, those on the east side to a height of 5,000 or 6,000 feet above the valley, or about 10,000 feet above sea level; those on the west side to not more than 8,000 feet above the sea.

The lake bottom lands form an uninterrupted level area. The level valley floor north of the lake lands is broken by Little Mountain, which covers a surface area of about 7 square miles, and reaches an altitude about 1,200 or 1,500 feet higher than the surrounding valley. One or two smaller hills, in the northwestern part of the valley, are the only other breaks in the general level, except the gorges cut by Bear and Malade rivers.

The mountains on the west side of the valley, as far as included in the survey, take a course a little east of north to the north side of T. 11 N., at which point the range doubles back on itself, forming a cove of about 10 square miles; from there it again turns and takes a course due north to the State line. This loop narrows the valley to a width of about 6 miles at the northern limit of the area.

Malade River enters the valley at the north end and flows into Bear River at Bear River City. Bear River enters the valley at the northeastern limit of the survey, and flows due south as far as Corinne, at which point it turns and flows almost due west into Great Salt Lake.

The area surveyed lies near the northern limit of what was formerly Lake Bonneville, this lake covering in earlier geologic times about two-thirds of the western part of Utah, with a narrow strip of eastern Nevada, and extending a short distance into Idaho on the north. Originally the upper shore of Lake Bonneville was about 1,000 feet above the present level of Great Salt Lake, and with the exception of a drop of 375 feet, due to an early outlet northward into Snake River, this whole body of water has gradually evaporated, leaving the present Great Salt Lake, Utah Lake, and Sevier Lake. Lake Bonneville lay wholly within the Great Basin, which includes practically all of the State of Nevada, three-fourths of the western part of Utah, a small corner of southeastern Idaho and southwestern Wyoming, and much of southern Oregon and southern California.

The Wasatch Range, in the area surveyed, is composed almost entirely of limestone and primary and secondary quartzite, with some shale, the former two overlying each other in alternate layers. This range has been greatly flexed and broken, forming in several places practically perpendicular walls of limestone and quartzite hundreds of feet high, facing the valley and showing dips of 50° to 60° northward. In a few places the dip is southward. Little Mountain and the mountains on the west side of the valley are also composed chiefly of limestone and quartzite. The Wasatch Range is broken just east of Brigham by Boxelder Canyon, and the creek issuing from this canyon has formed quite an extensive delta, on which Brigham is located. Other smaller and less important deltas have been formed all along the slopes of these mountains by wash from intermittent streams.

After Lake Bonneville had been confined to Salt Lake Valley the waters from Bear River, including the Cache Valley streams, flowed into Bear River Valley at the present entrance of Bear River, making deep deposits of soil in the northern end of the valley, consisting of fine sandy loam, fine sand, and sand. These deposits were later capped by clay loam and clay when the flowing waters were less in volume and the lake was shallower. As the lake receded Bear River gradually cut its way into its own deposits until at present the channel varies in depth from a few feet at Corinne to perhaps 150 feet near the mouth of the canyon. Malade River likewise cut a channel in these same deposits varying in depth from 10 to 50 feet within the area surveyed. This latter river, however, has not been an important agent in soil formation in the Bear River Valley. Numerous beds of shells exist in the northern part of the valley, and are sometimes cut into in canal excavations.

SOILS.

Thirteen soil types were recognized in the area surveyed. The following table shows the actual and relative extent of each type:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Salt Lake clay loam	70,656	33.2	Malade sandy loam	3,364	1.6
Jordan loam	61,632	28.8	Jordan clay	2,688	1.3
Fresno fine sandy loam	21,504	10.1	Bingham stony loam	1,984	1.0
Malade loam	16,640	7.8	Salt Lake sandy loam	1,498	.7
Bingham gravelly loam	10,304	4.8	Meadow	448	.0
Malade fine sandy loam	10,112	4.7	Total	213,682	
Salt Lake loam	6,912	3.2			
Malade fine sand	6,080	2.8			

The Jordan loam is a type of soil established in an earlier survey in this State, and is of considerable extent in Bear River Valley. As mapped in this area it consists of about 12 inches of gray, heavy fine sandy loam, underlain to a depth of from 2 to 3½ feet with loam, which becomes heavier with increased depth. From this point the subsoil consists of a clay loam, which usually grades into clay at from 4 to 6 feet. In small areas of local depression the third foot becomes clay, which continues to 6 feet.

There are two general areas of this type; one, and by far the largest, lies in the northern part of the valley, extending from the north end of Little Mountain northward to the limit of the survey. In this area the soil, especially the subsoil, is reddish in color, and contains considerable lime. The other group of areas is located on the east side of the valley, along the foot of the mountain slopes, partly extending into the low-lying lake bottom lands. In these areas both soil and subsoil are gray or black in color and, like the first-mentioned area, usually contain considerable lime. A light phase of this type is found in Boxelder Lake, which dries up every year, and in the cove north of Honeyville. In these areas the clay subsoil is found at a lower depth, and is sometimes entirely wanting in the 6-foot profile.

The areas occupied by the Jordan loam are usually level, and those on the east side of the valley are low and wet as well. The drainage is good where the type lies adjacent to Malade or Bear River, and in the extreme northern part of the area, next to the foothills and north of Honeyville. The remaining portions are poorly drained, especially Boxelder Lake and the areas at the foot of the mountain slopes on the east side of the valley, some of which are themselves drainage catchments for the surrounding land.

This soil type owes its origin to two modes of formation. In the northern part of the area it has been formed from sediment carried down by Bear River and deposited in Lake Bonneville when that lake was shallow. Probably much of the soil was deposited after the lake had receded from the northern part of the valley, by overflows and floods of Bear River before that stream had cut its present deep channel. The type in this part of the valley is distinctly stratified, and often contains beds of shells showing lake deposition. The southern and eastern areas have been formed partly by lake deposition and partly by wash from the mountain slopes.

Considerable quantities of alkali, or soluble salts, are found in this type in its southern and eastern locations and in that part lying west and north of Little Mountain. The extreme northern area of the type and that part lying north of Honeyville are free from harmful accumulations of alkali.

and sugar beets, and where naturally well drained, to alfalfa and orchard fruits.

The following table gives mechanical analyses of the soil and subsoil of the Jordan loam:

Mechanical analyses of Jordan loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11211	Cen. sec. 7, T. 10 N., R. 4 W.	Loam, 0 to 12 inches......	0.1	0.4	0.4	1.6	19.7	51.8	25.5
11476	W. cen. sec. 10, T. 11 N., R. 3 W.	Loam, 0 to 18 inches......	.1	.4	.2	1.4	6.4	53.9	37.4
11477	Subsoil of 11476......	Clay, 24 to 48 inches......	.1	.1	.1	.9	3.6	51.1	43.8
11212	Subsoil of 11211......	Clay, 24 to 36 inches......	.3	.3	.1	.4	5.3	45.1	48.4

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 11211, 24.5 per cent; No. 11212, 32.2 per cent.

SALT LAKE CLAY LOAM.

The soil of the Salt Lake clay loam, to a depth of about 12 inches, consists of heavy fine sandy loam, underlain to 6 feet with loam or heavy loam and, rarely, with clay loam. Occasionally a stratum of fine sandy loam or fine sand is found in the third, fourth, or fifth foot section, but this is not a necessary characteristic of the type.

The Salt Lake clay loam occurs in large areas in the southern and southwestern parts of the survey, representing the recent lake bottom; an area adjoining the east side of Little Mountain; smaller areas in and around Corinne, and other areas in the southern township of the survey, along the foot of the mountain slopes. All the areas are level, and those in the recent lake bottom are low and often wet. A few sloughs traverse the areas of this soil east of Little Mountain.

Where the Salt Lake clay loam adjoins Bear River or Malade River, it is well drained, but the remainder has poor natural drainage, and the water table is close to the surface. The recent lake-bottom area has, of course, no drainage at all, and is itself a drainage catchment basin for the whole valley. This area is often entirely covered with water in the spring, owing to the high water in Bear River. With the exception of those areas adjacent to Bear and Malade rivers and the bluff line indicated on the map, where drainage is good, the whole type is badly alkaline. There is an area west of Corinne, however, which is pretty well reclaimed.

The Salt Lake clay loam is of lacustrine origin. Only small areas of it are cultivated, chiefly in and around Corinne, to some extent east of Little Mountain, and in a few places on the east side of the valley, southwest of Brigham. Where not alkaline the type is cultivated to alfalfa and fruit, and to a small extent to grain. Many of the low-lying areas are devoted to hay production and grazing, to which the type is well adapted in its natural condition, especially south of Corinne and west of Brigham.

Some parts of this type in the recent lake bottoms sustain a heavy growth of coarse sedge, which is gathered for winter feed for cattle. These lake-bottom areas are also quite largely used for grazing purposes, as on many parts of them salt grasses grow fairly well, especially where copiously overflowed during the high water of Bear River.

The following table gives mechanical analyses of the Salt Lake clay loam:

Mechanical analyses of Salt Lake clay loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11203	N. cen. sec. 2, T. 9 N., R. 3 W.	Loam, 0 to 12 inches	0.1	0.5	0.6	6.5	30.5	43.4	18.3
11468	S. cen. sec. 36, T. 10 N., R. 3 W.	Heavy loam, 0 to 24 inches.	.3	.2	.3	3.7	20.4	51.8	22.9
11466	Cen. sec. 10, T. 10 N., R. 3 W.	Heavy loam, 0 to 18 inches.	.1	.5	.5	4.2	15.6	52.2	26.8
11202	Cen. of SW. ¼ sec. 21, T. 10 N., R. 4 W.	Heavy loam, 0 to 24 inches.	.0	.0	.1	.3	14.8	56.0	28.4
11469	Subsoil of 11468	Heavy loam, 24 to 48 inches.	.0	.2	.2	9.9	25.2	46.3	18.2
11467	Subsoil of 11466	Heavy loam, 24 to 48 inches.	1.1	1.5	.7	3.0	17.6	52.8	23.4
11204	Subsoil of 11203	Clay, 24 to 36 inches	.0	.1	.1	1.1	12.6	47.1	39.0

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 11202, 1.5 per cent; No. 11203, 5.2 per cent; No. 11204, 12.8 per cent.

MALADE LOAM.

The Malade loam consists of about 12 inches of fine sandy loam, underlain to 3 or 4 feet with loam, or sometimes clay loam, which is in turn underlain with fine sandy loam, sometimes extending to 6 feet, but more often grading into fine sand or sand in the lower part of the profile.

The type is located on the east side of Bear River, extending several miles south and west and 6 or 7 miles north of Corinne. A few small areas of bottom land along Bear River are composed of this type. The surface of the type is generally quite level.

The areas of Malade loam lying east of Bear River are generally well drained, owing to their proximity to the river channel. Those lying west and south of Corinne, however, are not naturally well drained, except where they adjoin the natural sloughs which intersect some portions of this type. The underground water map shows much of this type to have water within 3 to 6 feet of the surface, a considerable part of the area so affected being virgin land that has never been irrigated.

This soil type has been formed by deposits from the flood waters of Bear River, and these periods were succeeded by deposition in more quiet waters, probably during one of the temporary higher stages of the lake, before it reached anything like its present low stage. The areas lying east of Bear River are not badly affected with alkali, but those west and south of Corinne contain considerable alkali, especially in the subsoil. Where free from alkali the type is well adapted to sugar beets and grain, and, also, when the water is not too near the surface, to fruit and alfalfa.

The following table gives mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Malade loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11199	¼ S. of NW. cor. sec. 33, T. 10 N., R. 3 W.	Fine sandy loam, 0 to 12 inches.	0.0	0.4	0.9	25.2	25.8	32.7	15.0
11462	S. cen. sec. 26, T. 10 N., R. 3 W.	Loam, 0 to 12 inches	.3	1.0	.7	5.1	27.5	47.5	17.4
11459	N. cen. sec. 9, T. 9 N., R. 2 W.	Loam, 0 to 12 inches	.2	.4	.4	9.9	19.5	49.0	20.4
11200	Subsoil of 11199	Loam, 24 to 36 inches	.0	.2	.8	28.1	23.8	25.5	21.6
11463	Subsoil of 11462	Clay loam, 12 to 36 inches.	.0	.2	.1	3.3	29.4	36.7	30.2
11460	Subsoil of 11459	Heavy clay loam, 12 to 24 inches.	.7	1.7	.7	4.7	18.9	36.3	36.9
11201	Subsoil of 11200	Fine sandy loam, 48 to 60 inches.	.0	.2	.3	31.4	43.1	14.1	10.8

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 11199, 0.6 per cent; No. 11200, 8.1 per cent.

The Fresno fine sandy loam, as mapped in the Bear River Valley, consists usually of 6 feet of fine sandy loam, but in some parts of the area surveyed the subsoil from the fourth to the sixth foot, inclusive, is a sandy loam, the third-foot section, in local areas, being a light loam.

The type is found in nearly all parts of the survey, its principal occurrences being a few miles west of Corinne; west of Little Mountain; along the lower course of Malade River; scattered areas along Bear River from Corinne north to the limit of the survey; the cove northwest of Roweville, and smaller areas at the foot of the mountain slopes on both sides of the valley. Where the type occurs west of Little Mountain it is underlain with clay loam and clay, while in the other areas it is underlain usually with a lighter soil than the type itself.

The mountain slope areas of the type have, of course, the general slope of these places, while the remaining areas are level. West of Little Mountain, in the recent lake-bottom country, the type occupies local elevations left as little knolls and mounds, varying in height from a few feet to 15 or 20 feet above the lake-bottom land. These were formerly isolated islands. The surface of these areas is generally level. The type as a whole is well drained.

The areas west of Little Mountain have been formed by transporting the fine sandy loam from the surrounding hills and mountains, this having been deposited colluvially on top of the loam and clay formed from very much older lacustrine deposits. The areas along the mountain slopes owe their origin to the same agency, while those along the rivers have been formed from sediment carried by the water during overflows or when these channels were shallower than at present.

The type west of Little Mountain, and also that part west of Corinne, contains considerable alkali, but the remainder is practically free from harmful accumulations of salts.

Much of this type along the rivers is dry-farmed, owing to the difficulty of supplying it with water.

The Fresno fine sandy loam is well adapted to grain, sugar beets, alfalfa, and fruit. The area west of Little Mountain is not cultivated, owing to lack of water and to the presence of alkali.

The following table gives mechanical analyses of typical samples of the soil and subsoil of this type:

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.
			P. ct.	*P. ct.*	*P. ct.*
11206	¼ E. of cen. sec. 16, T. 10 N., R. 4 W.	Very fine sandy loam, 0 to 18 inches.	0.1	0.2	0.2
11470	NW. cor. sec. 24, T. 10 N., R. 3 W.	Fine sandy loam, 0 to 18 inches.	.3	.9	.9
11472	SE. cor. sec. 3, T. 9 N., R. 3 W.	Fine sandy loam, 0 to 12 inches.	.2	.7	1.3
11208	NE. cor. sec. 23, T. 10 N., R. 3 W.	Fine sandy loam, 0 to 12 inches.	.4	1.0	.8
11473	Subsoil of 11472......	Fine sandy loam, 24 to 48 inches.	.0	.4	.8
11471	Subsoil of 11470......	Fine sandy loam, 24 to 48 inches.	.0	.3	.5
11209	Subsoil of 11208......	Fine sandy loam, 24 to 36 inches.	.0	.1	.1
11207	Subsoil of 11206......	Loam, 36 to 60 inches.....	.3	.2	.1

The following samples contain more than one-half of 1 per cent of calci
No. 11206, 13.2 per cent; No. 11207, 16.8 per cent; No. 11208, 23.5 per cent; N

MALADE FINE SANDY LOAM.

The soil of the Malade fine sandy loam, to a depth
feet, consists of a gray fine sandy loam of the sam
Fresno fine sandy loam, underlain to 6 feet with loa
usually clay loam in the fifth and sixth foot section
red in color. This subsoil is about the same as th
Jordan loam, but is usually lighter in texture.

This type occurs in narrow strips of land along th
valley, usually occupying the lower portion of the
also in a small area at the foot of the mountain s
side of the valley, north of the Southern Pacific R
south of Corinne; and a long strip on the west sid
just back of the higher forelands adjacent to the riv

The type is generally well drained; that on the
valley because of the mountain slope, the lower pa
type occupies; and that along Bear River because of
the banks of that stream. The area south of Corinn
to the bluff, which also insures good natural draina

The heavy subsoil of this type has been deposite
from the silts and clays carried down by Bear Riv
covering of fine sandy loam has been formed coll
surrounding higher lying forelands along the riv
mountain slopes during later periods.

There is very little alkali in the Malade fine sandy loam, the heavy subsoil being comparatively free from it, owing to the good drainage conditions of the type.

The soil is cultivated principally to alfalfa, and some orchard fruits are grown. It is well adapted to sugar beets.

The following table gives mechanical analyses of typical samples of the soil and subsoil of this type:

Mechanical analyses of Malade fine sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11196	½ N. of SE. cor. sec. 10, T. 9 N., R. 3 W.	Fine sandy loam, 0 to 12 inches.	0.1	0.7	0.5	19.1	39.9	24.9	14.8
11455	S. cen. sec. 3, T. 11 N., R. 2 W	Loam, 0 to 24 inches	.1	.5	.9	10.6	24.2	48.6	15.0
11457	½ N. of SE. cor. sec. 10, T. 9 N., R. 3 W.	Fine sandy loam, 0 to 24 inches.	.1	.2	.3	18.0	28.0	36.6	16.5
11197	Subsoil of 11196	Fine sandy loam, 24 to 36 inches.	.1	.2	.1	15.3	38.6	26.5	19.0
11456	Subsoil of 11455	Clay loam, 24 to 48 inches.	.2	.5	1.3	13.5	18.5	39.4	26.7
11458	Subsoil of 11457	Clay loam, 24 to 48 inches.	.1	.1	.1	4.4	11.6	55.0	28.7

The following samples contain more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 11196, 5.2 per cent; No. 11197, 23.9 per cent.

MALADE FINE SAND.

The Malade fine sand consists of fine sand without much change in texture to a depth of 6 feet. It is located along the banks of Bear River, and extends from a point 2 miles south of Bear River City north to Collinston. The surface of the individual areas is usually level, but the more typical are usually raised above the surrounding land. A few local areas occur below the Bear River embankments, next to the stream itself.

The Malade fine sand has been formed from materials deposited by Bear River during overflows mainly before the channel reached its present depth. Some of these fine sand areas occupy high forelands along the river. The soil as a whole is well drained, and free from alkali.

The Malade fine sand is well adapted to any crop suited to the climate of the valley, and especially to sugar beets under irrigation.

The following table gives mechanical analyses of the soil and subsoil of this type:

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11454	N. cen. sec. 12, T. 11 N., R. 3 W.	Fine sand, 0 to 36 inches..	0.1	2.4	17.1	48.2	22.4	5.9	4.0
11453	N. cen. sec. 7, T. 11 N., R. 2 W.	Fine sand, 0 to 48 inches..	.0	.2	1.2	57.7	25.7	7.2	8.0
11226	S. cen. sec. 1, T. 11 N., R. 3 W.	Fine sand, 0 to 18 inches..	.0	.3	2.1	44.4	34.9	9.3	9.1
11227	Subsoil of 11226	Fine sand, 36 to 48 inches.	.0	.0	Tr.	35.2	38.6	16.2	10.1

The following sample contains more than one-half of 1 per cent of calcium carbonate ($CaCO_3$): No. 11226, 1 per cent.

MALADE SANDY LOAM.

The Malade sandy loam consists of about 12 inches of fine sandy loam, underlain to 5 feet with a coarse sandy loam, often containing a high percentage of clay; and this, in turn, is underlain to 6 feet with a fine sandy loam or fine sand. The surface foot is usually quite loose in texture, but below that the soil is generally very compact.

The type is located on the east side of Bear River, adjacent to that stream, and extends from Corinne north to Bear River City. The surface is level, but higher than the surrounding land, the sandy loam occupying the forelands along the river.

The type owes its origin to deposits from Bear River during overflows. It is well drained and free from alkali.

This soil is well adapted to any crop grown in the area, and is one of the best soils for sugar beets when irrigation is practiced. It was dry-farmed to some extent before the East Side Canal was built.

The following table gives a mechanical analysis of a typical sample of this soil:

Mechanical analysis of Malade sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11465	NE. cor. sec. 9, T. 10 N., R. 2 W.	Sandy loam, 0 to 24 inches.	0.0	0.2	0.7	45.8	23.3	10.2	19.8

The Bingham gravelly loam consists of a fine sandy loam or loamy sand containing considerable gravel, especially in the subsoil. The gravel varies in size from fine gravel to fragments 3 or 4 inches in diameter. As mapped in this area the gravel usually reaches the surface, but may be from 1 to 2 feet below. In some places there is very little interstitial soil, this being the case where the slopes are steepest and the water action greatest.

The type is located on the east side of the valley, along the slopes of the mountains. A few isolated areas occur in other parts of the valley. The soil is well drained and free from alkali.

The Bingham gravelly loam has been formed entirely from wash from the hills and mountains, and numerous small deltas have been formed by the intermittent streams. The largest delta area, on which the city of Brigham is located, occurs at the mouth of Boxelder Creek.

The type is important, owing to its adaptation to fruit and truck farming, and is devoted largely to orchard fruits, consisting of apples, pears, peaches, apricots, plums, and cherries. Small fruits, particularly strawberries and raspberries, and considerable quantities of vegetables are grown, these often being cultivated as intermediary crops in the orchards.

This type of soil occurs in several other areas already surveyed in Utah, and the following analyses of samples taken in the Salt Lake survey will serve to show the texture of the interstitial material:

Mechanical analyses of Bingham gravelly loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
4362	SW. ¼ sec. 15, T. 3 S., R. 2 W.	Fine sandy loam, 0 to 15 inches.	1.50	2.71	5.81	8.87	27.93	38.21	13.58
4363	S. cen. sec. 24, T. 2 S., R. 2 W.	Fine sandy loam, 0 to 15 inches.	.66	1.77	7.71	8.50	28.71	36.57	15.96
4312	SW. ¼ sec. 2, T. 2 S., R. 2 W.	Fine sandy loam, 0 to 12 inches.	7.57	2.64	2.88	7.29	13.06	41.46	18.15
4318	SE. ¼ sec. 34, T. 3 S., R. 2 W.	Fine sandy loam, 0 to 15 inches.	.33	.77	2.48	4.09	15.73	43.99	22.66

JORDAN CLAY.

The Jordan clay consists of about 12 inches of clay loam or clay, underlain to 6 feet with stiff, tenacious gray or yellow clay. Occaat any depth between the second and sixth foot sections.

This type occurs at the lower limit of the mountain slopes on the east side of the valley, in the southern township, and extending into the recent lake bottom of Great Salt Lake. It is low lying, often wet or poorly drained, and contains considerable soluble salts. It is lacustrine and colluvial in origin, and is of no value except for pasturage during the summer.

The following table gives mechanical analyses of typical samples of the soil and subsoil of the Jordan clay:

Mechanical analyses of Jordan clay.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11480	SW. cor. sec. 15, T. 9 N., R. 2 W.	Clay loam, 0 to 24 inches	0.1	0.5	0.5	13.0	22.0	31.7	32.3
11478	¼ W. of E. cen. sec. 10, T. 9 N., R. 2 W.	Clay, 0 to 24 inches	.3	.6	.5	5.8	13.2	32.5	47.3
11479	Subsoil of 11478	Clay, 24 to 48 inches	.2	.4	.4	5.5	19.3	39.7	34.0
11481	Subsoil of 11480	Clay, 24 to 48 inches	.0	.4	.4	9.9	15.4	38.4	35.4

SALT LAKE LOAM.

The Salt Lake loam consists of from 2 to 3½ feet of loam, very fine in texture and grading into clay loam, and underlain to 6 feet with fine sandy loam, fine sand, or sandy loam.

The type is found only in the lake bottom, having been formerly, as late as the early seventies, in fact, part of the bed of Great Salt Lake. It is very level and very poorly drained. It was deposited in the lake from sediment carried down by the streams, and contains an excessive amount of alkali, both in the soil and subsoil.

On some parts of the type, where there is a considerable overflow of Bear River during the spring, a rank growth of sedge flourishes. The only value of the type consists in this sedge, which is cut for winter feed, and in the grazing it affords.

The following table gives mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Salt Lake loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11482	Cen. sec. 5, T. 8 N., R. 2 W.	Loam, 0 to 24 inches	0.2	0.2	0.4	9.0	23.3	43.4	23.5
11483	Subsoil of 11482	Sandy loam, 24 to 48 inches.	.1	.5	2.4	34.3	31.1	20.6	10.9

SALT LAKE SANDY LOAM.

The Salt Lake sandy loam consists of 6 feet of sandy loam, usually coarse in texture, and generally interstratified with either fine sandy loam, sand, fine sand, or light loam. The type as mapped in this area shows considerable variation in texture.

This soil is found in what was formerly the bottom of Great Salt Lake, and was deposited in the lake by sediment and wash from the mountains and river. It is excessively salty, and is of no value except in a limited way for grazing in spring and summer.

MEADOW.

Meadow is a type of but small extent in the area surveyed, and consists of from 2 to 3 feet of loam, containing in the surface foot considerable muck, underlain with gravelly loam or gravel.

The type is located in small areas north and southwest of Brigham; is low lying, poorly drained, free from alkali, and is used both for pasturage and the production of hay.

BINGHAM STONY LOAM.

The Bingham stony loam is an unimportant type, of little or no agricultural value, found at the base of the mountains along the east side of the valley. It is used along with the mountains for grazing purposes.

HARDPAN.

A few small areas of hardpan were found northwest of Willard and northwest of Corinne, but there is no general distribution of it in the valley. It was noticed, in fact, in only two borings at 2 or 3 feet below the surface, and consisted of 1 or 2 inches of soil cemented together with lime carbonate. Quite often small particles of hardpan, the size of fine gravel or coarse sand, were found, but these seemed to occur loose in the soil and not in compact layers.

WATER SUPPLY FOR IRRIGATION.

The Bear River canal system is the most extensive and important factor in the irrigation of Bear River Valley lands. It covers practically all the irrigable land between Bear River and the mountains on the west side of the valley and extends from the northern end of the valley south to and beyond Corinne. This canal was built in the late eighties and early nineties by foreign capital, but owing to financial and other difficulties it was not at first a success. It is said to have cost approximately $2,000,000 to complete it. It is now successfully operated by the present owning company.

The capacity of the canal at the intake is 600 second-feet, and it irrigates at present about 34,000 acres, with a total capacity of 50,000 acres. A permanent water right costs $25 an acre, but does not carry with it any ownership or stock in the canal. The annual water rental is $1 an acre, which amount is paid whether the water is actually used or not. For this sum the irrigator is allowed water at the rate of 1 second-foot per 80 acres, which is equivalent to about 34 acre-inches per season. Some of the higher lying and better drained land can use this amount safely, but much of the level and lower lying land ought not to have so much water applied to it, as it is more economical to use less water than is actually paid for than to raise the underground water table too near the surface.

In 1903 and 1904 another canal was built on the east side of Bear River, called the "East Side Canal," and from this a branch canal was built along the mountain slope on the east side of the valley. The East Side Canal gets its water from the Bear River Canal at Bear River Canyon, paying the older company a certain rental for the water thus obtained. The Bear River Canal, however, has the priority of right, and in years of scant water supply the East Side Canal must surrender its water to the other company. During a season like 1904, however, there is sufficient water for all concerned.

The following is the laboratory analysis of water taken from the Bear River Canal near Trenton on July 27, 1904. The Water, as will be noticed, is of excellent quality. For purposes of comparison, the analysis of water from Salt Creek, taken on the same day at the source of that stream, is added.

Chemical analyses of irrigation water.

[Parts per 100,000.]

Constituent.	No. 312, canal water, Bear River, SW. cor. sec. 1, T. 11 N., R. 3 W.	No. 313, Salt Creek water, S. cen. sec. 6, T. 11 N., R. 3 W.	Constituent.	No. 312, canal water, Bear River, SW. cor. sec. 1, T. 11 N., R. 3 W.	No. 313, Salt Creek water, S. cen. sec. 6, T. 11 N., R. 3 W.
Ions:			Conventional combinations:		
Calcium (Ca)	5.4	7.1	Calcium sulphate ($CaSO_4$)	5.7	11.2
Magnesium (Mg)	2.7	3.4	Calcium bicarbonate ($Ca(HCO_3)_2$)	6.4	....
Sodium (Na)	3.5	63.2	Calcium chloride ($CaCl_2$)	5.7	10.5
Potassium (K)	2.2	4.0	Magnesium bicarbonate ($Mg(HCO_3)_2$)	16.2	....
Sulphuric acid (SO_4)	4.0	7.9	Potassium chloride (KCl)	4.2	7.6
Chlorine (Cl)	5.6	100.9	Sodium bicarbonate ($NaHCO_3$)	9.8	36.6
Bicarbonic acid (HCO_3)	25.4	26.6	Sodium carbonate (Na_2CO_3)	1.9	1.9
Carbonic acid (CO_3)	1.1	1.1	Magnesium chloride ($MgCl_2$)	....	13.3
			Sodium chloride (NaCl)	....	133.1
			Total solids	49.9	214.2

The following table gives measurements of the discharge of Bear River at Collinston, as furnished by Prof. George L. Swendsen, of the United States Geological Survey:

Discharge measurements of Bear River.

Date of measurement.	Discharge in second-feet.	Date of measurement.	Discharge in second-feet.	Date of measurement.	Discharge in second-feet.	Date of measurement.	Discharge in second-feet.
1900.		1900.		1902.		1903.	
Feb. 17	1,567	Dec. 26	862	July 16	324	Aug. 28	30.6
Mar. 31	2,228	1901.		July 20	205	Oct. 24	302.6
Apr. 30	3,671	Feb. 18	1,415	Aug. 18	68	Nov. 19	722
May 20	3,775	May 27	4,274	Aug. 26	60	1904.	
June 29	1,158	July 31	264	1903.		Jan. 29	641.8
July 26	627	Aug. 30	377	Jan. 5	349	Mar. 5	2,199
Aug. 28	542	Sept. 14	392	Apr. 6	2,332	May 10	6,334
Sept. 24	831	Oct. 21	973	May 30	2,863	June 8	5,172.6
Oct. 29	819			July 1	1,366	July 7	1,803.3
Nov. 12	1,336						

These measurements, being taken near Collinston, represent the flow after the Bear River Canal and East Side Canal have taken their water. The discharge shows great irregularity from year to year, being extremely high in 1904 and low in 1902 and 1903. The canals are in use from May to October.

in the area surveyed, irrigates the delta on which the city of Brigham is located, as well as some of the surrounding lower lying meadow and hay land. The entire creek is used, and much more water could be profitably utilized were it obtainable. The discharge of the creek varies greatly from spring to fall, but, as a rule, does not fall below a certain minimum in any year. The source of the creek is a few miles up Boxelder Canyon. The average minimum discharge is said to be about 24 second-feet, and with this about 2,500 acres are irrigated, which is an allowance of 1 second-foot per 104 acres. The creek is divided among the irrigators in such a manner that all share the surplus or deficiency, a certain fraction of the flow being directed to its proportional amount of land. The present irrigators hold the water by priority, and a share—which means the privilege of using a certain fraction of the stream for a certain number of hours per week—sometimes sells for as much as $150. Shares on a sixteenth part of the creek have been sold for that price, and a share on an eighth or larger fraction of the stream would, of course, cost more.

There are a number of other smaller streams that are used, all along the slope of the Wasatch Mountain Range and all originating but a short distance back in the mountains. Some of these are piped down the mountain slopes, and all are distributed among the landowners in the manner in which Boxelder Creek is apportioned. The water of these streams is of excellent quality, not only for irrigation, but for domestic use as well.

Some small areas in the northern part of the valley are dry-farmed, usually to wheat, and in seasons as favorable as 1904 good crops are obtained. Dry-farmed wheat yields from 10 to 30 bushels per acre.

UNDERGROUND AND SEEPAGE WATERS.

A map was constructed showing the depth to standing water in the area at the time of the survey. While this depth will vary during the season, being greater during a wet spring and less during the summer, and influenced locally, or even generally, by irrigation, the map, nevertheless, shows very closely the position of the underground water table. The importance of keeping the water under control can not well be exaggerated, as the underground water primarily governs the alkali conditions, especially in the large level areas where this water is normally near the surface and the natural underground drainage is not good.

The extent of the various areas of underground water, as classified on the map according to depth, is shown in the table following.

Areas of underground water.

Depth.	Acres.	Per cent.
Less than 3 feet	64,640	30.3
From 3 to 6 feet	57,216	26.7
From 6 to 10 feet	39,808	18.6
Over 10 feet	51,968	24.3
Total	213,632	....

The underground water was tested frequently in various parts of the area, as were also some of the natural springs. As would be expected, considering the general distribution of alkali in the subsoil, the underground water is often very salty. This is especially true of the level area north and west of Corinne, up to and including Tremont. The surface well waters examined contained from 150 to 500 parts of salts per 100,000 parts of water. These salts consisted principally of chlorides, with some bicarbonates, and from 3 to 20 parts of alkaline carbonates, or black alkali. Sulphates were not often present.

The deeper seated waters are more salty, generally, than the surface well waters, especially west of Bear River. This has often been learned from experience in attempting to obtain better water by passing the first stratum of surface well water.

The underground water along the east side of the valley is very good, containing very little alkali. Many successful artesian wells have been drilled in T. 8 N., R. 2 W., but efforts in this line in the northern part of the valley have not yet been successful. The water from the flowing wells mentioned is of very good quality.

There are many salty springs in the area, especially at the south end and west side of Little Mountain. These contain from 2,000 to 3,000 parts of salts per 100,000 parts of water, and vary in temperature from 70° to 105° F.

Quite often gas is found in drilling artesian wells in the southern part of the area. These gas reservoirs are found at 90 feet and deeper, but they are generally of but temporary endurance, though one was used for more than a year for burning brick.

One of the best indicators of future alkali conditions is the position of the underground water table. As will be seen from the map, the water is already dangerously near the surface in the western part of the valley. A great many factors must be considered in determining how near the surface the water table may approach with safety—such as the character of the soil and subsoil, fall of the land, whether the alkali is in the subsoil or naturally near the surface, whether shallow or deep rooted crops are to be grown, and, most important of all, whether the irrigator can control his tendency to use water too freely.

Drainage of the area north and west of Corinne, up to within 3 or 4 miles of Tremont, will be necessary in order to render this as yet virgin land suitable and safe for cultivation, for the water table is already too near the surface. This condition is attributable partly to the canals traversing the area, partly to the drainage from the irrigated lands farther north, and largely to the almost perfect levelness of the land. The drainage scheme for this kind of land must necessarily be quite comprehensive in scope, and it would generally be impracticable for individual farmers to drain isolated farms. This could be done, however, by those whose lands are adjacent to the natural sloughs that traverse some parts of the area. Beginning 2 or 3 miles north of Little Mountain and running south along the east side of the mountain is a series of natural sloughs well able to receive drainage water from the surrounding country. Another system of sloughs is found in the southern half of T. 10 N., R. 3 W., entering and traversing part of T. 9 N., and finally emptying into Bear River Bay. These sloughs would be of great value as common main drains. T. 11 N., R. 3 and 4 W., could be drained into the swamp located in the southeastern corner of T. 11 N., R. 4 W. This swamp has an outlet south into the lake bottom country.

Another area where drainage is practicable is Boxelder Lake. This intermittent lake, which dries up during the summer months, occupies about 7 or 8 square miles in T. 10 N., R. 2 W., adjoining the Oregon Short Line Railroad track, and partly traversed by the latter, and extends about 1 mile into T. 9 N., R. 2 W. This lake receives the drainage from mountain slopes and from sloughs west of Honeyville, and already has a natural outlet slough, which drains southwestwardly into the lake bottom land, but no attempt is made to deepen it or to keep it clean, and in its present condition it is inadequate to carry off the surplus water. This basin receives an enormous quantity of water during winter, which would greatly assist in the reclamation of the land.

People farming in the western part of the valley complain that two or three years' irrigation ruins the land by bringing up the alkali, and that there was no alkali when they began farming. The fact is that the alkali is in the subsoil, and under certain conditions soon comes to the surface. Land in which the alkali amounts to 0.6 per cent or more in the first 6 feet will certainly give trouble when excessively irrigated, if suitable drainage is not provided.

ALKALI IN SOILS.

The usual method of determining the soluble salt content, viz, by the electrical resistance offered to a water-saturated portion of the soil, was used in this survey. The alkali map represents the average salt content thus determined to a depth of 6 feet, each foot section being determined separately.

The actual and relative extent of the various grades of alkali soils, as shown on the map, are given in the following table:

Areas of alkali land.

Grade.	Acres.	Per cent.
Less than 0.2 per cent	75,584	35.4
From 0.2 to 0.4 per cent	11,648	5.5
From 0.4 to 0.6 per cent	8,000	3.7
From 0.6 to 1 per cent	14,528	6.8
From 1 to 3 per cent	25,280	11.8
Over 3 per cent	78,592	36.8
Total	213,632	....

The alkali areas are located in the southern, western, and southwestern parts of the survey, extending from 4 to 6 miles in all directions from Little Mountain; and there is also an area in Boxelder Lake, beginning about 2 miles north of Brigham. The only areas entirely free from alkali are in the northern end of the valley from Tremont north to the limit of the survey, in the extreme northwestern part of the survey and along the mountain slope on the east side of the valley. The areas of greatest salt content are located chiefly in what was formerly part of Great Salt Lake—that is, since it became practically concentrated with salt—and in the beds of Boxelder Lake. In these areas the average salt content for the first 6 feet is anywhere from 3.50 per cent to 10 per cent.

As has been mentioned in another part of this report, Salt Lake Valley, the northern end of which is called Bear River Valley, lies in what was in earlier geologic times Lake Bonneville. This immense body of water was mostly evaporated, and was finally confined to the Salt Lake Valley. As evaporation proceeded and the lake lowered, the water became more saline, due to concentration of the solution, and as it receded from the northern end of the valley it left the soil impregnated with its contained salts. As the lake dwindled in size it became more and more salty, leaving the bottom land next to its shores heavily impregnated with alkali. All the alkali in the area owes its origin to this process of lake recession and concentration.

The alkali is composed principally of chlorides, by far the largest constituent being sodium chloride or common salt. There are also limited quantities of alkaline carbonates and hydrogen carbonates, but sulphates are very seldom found. The alkaline carbonates (black alkali) were found practically everywhere in very small quantities, both in the soil and the subsoil, but with one or two exceptions tests showed less than 0.05 per cent. The underground water almost always contained black alkali. There are many local black-looking alkali spots throughout the area that are commonly supposed to be chiefly alkaline carbonates, but tests never showed more than traces, the principal constituents being chloride and some bicarbonates.

In order to make the alkali conditions more readily apparent and to increase the value of the alkali map, a legend was adopted and used on the alkali map to show the salt content of the surface foot of soil. By this it will be seen that almost invariably, with the exception of the lake bottom land, the surface foot contains less alkali than the average for the first 6 feet. This is often true also of the second foot section, and in some places even of the third foot of soil. Generally the maximum salt content was found in the third or fourth foot section, but sometimes as deep as the sixth foot. Borings made to a depth of 10 feet showed very little change in salt content from the fifth to the tenth foot.

Because of the fact that the surface soil to a depth of 1 or 2 feet is very often comparatively free from alkali, a native growth of sagebrush, rabbit bush, flowers, and grasses often prevails where the average salt content for the first 6 feet of soil is from 1 per cent to 3 per cent. By these conditions the people are often led to believe that the soil is free from alkali. When, however, such vegetation as young greasewood, samphire, salt grasses, etc., predominates, the alkali is not far below the surface.

In arid regions where irrigation is practiced the question of the reclamation of alkali lands always arises sooner or later, even if the soils are at first free from alkali, and especially if irrigation is too lavishly practiced. In a large part of Bear River Valley the question comes up immediately upon attempting to cultivate the land, as much of it is already heavily impregnated with salts.

The most permanent method of reclaiming alkali land is by artificial underground drainage and flooding combined. It should be strongly urged, however, that only enough water be used in the present cultivation of crops to satisfy immediate plant needs, thus taking precautionary measures against the surface accumulation of alkali. If this precaution were taken when the land is first brought under cultivation, the necessity for underdrainage would be greatly postponed. When the subsoil is alkaline and the water table is within 5 or 6 feet of the surface, it is worse than folly to saturate the soil and subsoil simply because there happens to be water enough to do so. The crops can use but a certain amount of this moisture, and can obtain it as well, and live under more favorable circumstances, if only enough water is used to satisfy them.

That two or three years' irrigation will materially raise the water table was interestingly shown in a few places where isolated farms surrounded by virgin unirrigated land had been farmed and irrigated for that length of time. The water table in the cultivated fields was 3 or 4 feet higher than in the surrounding virgin soil. A cheap, convenient, and valuable instrument for a farmer to possess is an inch or inch and a quarter auger, with a 6-foot handle welded on, by the use of which the irrigator can keep himself informed of the position of the underground water table, and also judge better of the amount of moisture in the soil, thus making the application of water an intelligent operation rather than a mere guess.

Some questions were asked and a few complaints made about the effect of the water in the mill race on the land which it traverses on its way to Corinne Mills. This water is taken out of Salt Creek about 1½ miles below the source of that stream, and traverses considerable land on its way down. It no doubt influences the underground water table along its course, just as any canal would, but that it brings much alkali to the land does not seem probable. This stream was examined at its source and was found to contain 214 parts of salts in 100,000 parts of water. A glance at the alkali map will show that it traverses land carrying 0.60 per cent or more of alkali in the first 6 feet. Now, 214 parts of salts in 100,000 parts of water is equivalent to about 0.07 per cent of salt in soil of a loam texture. There could thus hardly be any addition of alkali to the soil from such water. Furthermore, this creek was also tested on the south side of section 27, T. 10 N., R. 3 W., after crossing practically two townships, and was found to contain 295 parts of salts per 100,000 parts water, an increase in salt content of 81 parts.

RESISTANCE OF PLANTS TO ALKALI.

Some data were obtained concerning the amount of alkali that crops in the valley would withstand. As the alkali conditions change more or less during the growing season, due to surface evaporation, irrigation, etc., the data can not be regarded as absolute, but the information may be of value.

Young wheat was found doing well with from 0.50 to 0.56 per cent of salt in the surface foot, and oats were growing not quite so favorably; both crops, however, would apparently mature satisfactorily.

During the spring, when sugar beets were young, tests were made at the root crowns of beets that seemed to be growing in their limit of alkali, and the amount of soluble salt found in the first foot was 1.52 per cent. No examination was made of the second foot. Late in the summer, however, the same field was visited and borings were made in the same alkali spot, and it was found that beets were growing well and would mature in soil carrying from 2.50 per cent to 4.70 per cent in the surface foot, with 0.42 per cent to 0.84 per cent in the second foot. These were isolated beets growing in alkali spots that had killed out most of those planted. As the surface foot of soil carried more salt in late summer than in spring, when the field was first examined, and as the beets mentioned were well able to mature, it would seem that 1.50 per cent of alkali in the surface foot was not more than beets could endure. Examinations made at the same time in the best part of the field, where a crop of 20 tons per acre might be expected, showed 0.47 per cent in the first foot and 0.33 per cent in the second foot.

The fact that the sugar beets were found to grow in such a high percentage of alkali seems at first sight somewhat strange, but the amount of alkali in which a crop is found growing at any one time tells very little of the life history of that crop. Because sugar beets were found growing in from 3 to 4.70 per cent of alkali in the surface foot of soil late in summer does not argue that the same sugar beets would have been able to resist such quantities in their younger stage, and in fact they did not do so.

In the early part of the season, when the beets were 4 or 5 inches high, it was found that 1.50 per cent of soluble salts in the first foot was about the maximum content that the beets could stand. Other plants were examined that were dying, but in no case was it found that any of these were growing in less than 1.50 per cent. As this was early in the season and the ground was yet quite moist, owing to the late spring rains, the alkali was not yet so much concentrated at the surface as it was later in the season. Even in the earlier tests, however, there was a slight concentration of alkali at the surface, below which the beet roots were growing, so that the roots themselves were probably growing in a little less than 1.50 per cent alkali. As they grew they naturally increased in resistance, and so were able to withstand the gradually increasing amount of surface alkali. In the latter part of the season there was a heavy incrustation of alkali on the surface of the soil, which probably did exert a proportionally increased deleterious effect on the growth of the beets, but the active absorbing portions of the roots were below it. The concentration of the second foot, however, shows that even the young plants were growing in the presence of considerable alkali.

An interesting case of alfalfa growing in alkali soil was found in section 31, T. 10 N., R. 3 W. A heavy, well-matured crop was growing in soil containing the following percentages of salt from the first to the sixth foot, respectively: 0.14, 0.27, 0.43, 2.00, 3.12, and 3.75—an average of 1.62 per cent; and there was standing water at 4 feet. It may be that the roots of the alfalfa had accommodated themselves to the existing conditions and were confined to the first 3 or 4 feet of soil, though in view of the deep-rooted character of the crop it is hardly supposable that such was the case. The water table was probably temporarily high owing to recent irrigation. This case demonstrates what can be done with alkali land if properly irrigated and the subsoil water not allowed to carry salt to the surface. A crop will germinate in but a small proportion of the amount of alkali which it will endure when once well started; hence more care must be exercised in getting a good stand than is necessary to carry a crop to maturity.

An apple and peach orchard was found dying in section 1, T. 9 N., R. 3 W., where the salt content, in percentages from the first to the sixth foot, respectively, was as follows: 0.09, 0.16, 0.39, 0.48, 0.69, and 0.86, an average of 0.44 per cent. Standing water was here at 4 feet below the surface, and this is not a good test as to the effect of alkali alone, as with the water table so near the surface it, also, would be likely to interfere with the proper development of the trees. It is quite probable that if the water table had been 2 or 3 feet lower the trees would have been able to stand the amount of alkali found.

Owing to the recession of Great Salt Lake, large areas of lake-bottom land have been formed in the southern and southwestern parts of the survey. The water is usually within 2 or 3 feet of the surface, and the soil is excessively salty, containing more than 3 per cent in the first foot, with increasing amounts at greater depths. However, large tracts of this land support a heavy crop of sedge wherever Bear River overflows it copiously during the late winter and spring. Tests in heavy growths of this sedge showed from 3 to 5 per cent of alkali in the first foot, with increasing salt content in the subsoil. Large quantities of this plant are harvested for winter feed. and while not a choice hay, it is fed to cattle until the spring. Grasses are grown in small quantities on the same land, which makes it valuable for summer grazing. The following varieties, which were determined by Professor Spillman, promise to be of considerable value for such land: *Distichlis spicata*, *Polypogon monspeliensis* (beard grass), *Scirpus maritimus* (sedge), and *Puccinellia airoides* (slender meadow grass). The last-named grass should be cultivated in preference to the coarse sedge, as it is much more succulent for feeding, though the yields are not so large.

AGRICULTURAL CONDITIONS.

The farming class in the Bear River Valley are evidently prosperous, and there is every indication that this prosperity will continue in the future. The homes and farms on the eastern side of the valley, which was settled first, are generally free from debt, but the farms on the western side of the valley, especially in the northern part of this section, are yet quite heavily mortgaged, many of them being entirely new or of only a few years' cultivation. The farm dwellings are neat in appearance and well built, but are often without good outbuildings.

The Twelfth Census reports the value of farm lands and improvements (except buildings) for Boxelder County, in which the present soil survey was made, as $2,636,160; farm buildings, $510,990, and farm implements and machinery, $204,990. The census of 1900 also shows that 80 per cent of the farms of the county are operated by their owners.

The average size of farms along the eastern side of the valley, east of Bear River, is less than that of those on the west side. The eastern side, being the first settled, was subject to the restrictions in size imposed at that time, and so generally practiced during the early Mormon occupation of the State. The average size of farms in the county, according to the Twelfth Census, is 561.1 acres and the number of farms is 1,020. This, however, includes much land not yet cultivated, as the acreage of improved farms is only 20 per cent of the entire acreage owned as farms. The data mentioned above, however, refer to conditions existing in 1900, and at the present time the percentage of improved land is undoubtedly greater, owing to better facilities for irrigation and for marketing crops, especially in the northern part of the valley.

The farming population is composed chiefly of whites, including many nationalities. There are very few negroes or Chinese in the valley. During the last two years prominence has been given to the sugar-beet industry, and the labor in the beet fields is largely performed by Japanese. The expenditure for labor in 1900 for the county was $128,890, an average of $130 per farm. On many farms, however, little or no labor is employed, the work being done by the family. Labor is hired principally for the harvesting of the hay and grain crops.

Of the general farm products the largest acreage is in wheat, followed by alfalfa, there being only a small difference in the acreage and value of each of these crops. There is a large acreage in wild and cultivated grasses, and also in barley. It is now claimed that 3,000 acres in the area are planted to sugar beets. Wheat yields from 25 to 40 bushels, barley from 40 to 60 bushels, and oats from 50 to 120 bushels per acre, all under irrigation. Alfalfa, by far the most important hay crop, yields three or four cuttings each year, amounting to from 5 to 8 tons per acre, depending on the seasons, and there is usually good pasturage after the last crop is removed. It sells at from $3 to $4 in the stack in the fall, from $4 to $5 during winter, and when baled and shipped to Salt Lake City at from $7 to $9 a ton.

Considerable early truck is grown along the slopes of the Wasatch Mountain Range, especially in and around Brigham. Orchard and small fruits are also important crops on the gravelly delta on which of a good market. Until a few years ago the orchard fruits were confined to the eastern mountain slopes, but recently the people in the western part of the valley have become interested, with the result that many orchards are being set out, while others started a few years ago are just beginning to bear. Apples constitute the principal fruit, and peaches and apricots are next in importance. Pears were extensively set out when interest was first aroused in this industry; but, unfortunately, the pear blight has killed nearly every tree in the western part of the valley. This disease does not attack so readily the fruit trees on the east side of the valley, on the gravelly mountain slopes. It is estimated that the annual sales of orchard fruits, small fruits, melons, and cantaloupes produced in and around Brigham amount to about $100,000, and in the whole county to about $150,000. Tomatoes are an important crop, and many of these, together with orchard fruits, are canned, there being two canneries in the area, one at Brigham and one at Willard.

Sugar beets have become one of the important crops during the last two years (1903, 1904). A factory was built at Garland in 1903, and in 1904 3,000 acres were cultivated to sugar beets, principally in the northern end of the valley. The price paid for them is a flat rate of $4.50 a ton delivered at the factory, or from $4 to $4.25 on cars. Some of the soils are excellently adapted to sugar beets, and in some parts of the area as high a yield as 40 tons per acre has been secured. It is estimated that the average yield is from 12 to 15 tons per acre.

Other important industries are cattle and sheep raising. The stock range in the Wasatch Mountains during the summer season, and are brought back to the mountain range on the west side—Promontory Range—for the winter, except those fed in the valley for special purposes. According to the Twelfth Census, the value of live stock in Boxelder County was over $1,000,000, and of dairy products about $55,000.

The recognition of the adaptation of soils to crops is considered only for vegetable and truck crops, and to a certain extent for sugar beets. In the general farming in the valley, however, by far the most important consideration is whether the desired crop can be grown without being killed out by the alkali already present in the surface or by that which will probably come to the surface after irrigation. This is perhaps of more significance than the texture of soils as adapted to crops, for any crop seems to do well on any type of soil if the alkali and underground water are kept under control.

The gravelly soils along the east side of the valley are devoted to orchard fruits, small fruits, melons, cantaloupes, tomatoes, etc. The new land in the western and central parts of the valley, when cleared of its native growth of sagebrush and greasewood, is generally planted to cereals—usually wheat—which may be spring or fall sown. After two or three years' cultivation to this crop the usual practice is to plant the land to alfalfa. The previous cultivation puts the land into good mechanical condition and enables it to be properly leveled and checked for permanent irrigation. It is often doubtful, however, if this practice is of universal value, as the two or three years' cereal cultivation often brings the subsoil alkali to the surface, thus making it difficult to obtain a good stand of alfalfa. When it is desired to grow alfalfa on land where there is danger of a rise of alkali, it would be a better practice to put the soil into good mechanical condition, sow the alfalfa seed at once, and at the same time put in a nurse crop. The alfalfa will resist considerably more alkali after a stand is obtained than it will in germinating and beginning its growth. The alkali map will be of considerable assistance in determining which method should be employed.

The transportation facilities in the area are good, the valley being traversed north and south along the east side by the Oregon Short Line Railroad, and east and west by the Southern Pacific Railroad, via Corinne, and by a branch of the Oregon Short Line from Brigham to Garland via Corinne, on the west side of Bear River. This branch railroad is to be extended to Malad City, Idaho.

Many of the farm products, especially alfalfa, are sold in the local market. Much alfalfa, and also most of the fruit, is sold to commission houses or shipped direct to Salt Lake City, part of it being sold there, though a great deal is shipped to Montana, Idaho, Nevada, and Wyoming. There are good markets for all crops raised.

SOIL SURVEY OF THE YUMA AREA, ARIZONA-CALIFORNIA.

By J. GARNETT HOLMES, CHARLES A. JENSEN, HERBERT W. MAREAN, N. P. NEILL, ALDERT S. ROOT, W. E. McLENDON, J. L. BURGESS, A. T. STRAHORN, and A. T. SWEET.

LOCATION AND BOUNDARIES OF THE AREA.

The soil survey work of 1903 along the lower Colorado River, in the vicinity of Yuma, is a continuation of the work done by the Bureau in the winter of 1901–2. At that time a survey was made of what is locally known as Yuma Valley, which comprises the bottom lands from Yuma along the Arizona side of the river to the Mexican boundary line. The present work comprises all other lands on both sides of the river which it is possible to irrigate from the proposed Government canal to be diverted at some point near the Yuma dam site, as shown upon the map. Roughly speaking, the land that can be irrigated in this way all lies below the 200-foot contour line. Yuma is situated on the Arizona side of the Colorado River, about 20 miles from the Mexican boundary and about 21 miles from the dam and heading of the proposed canal.

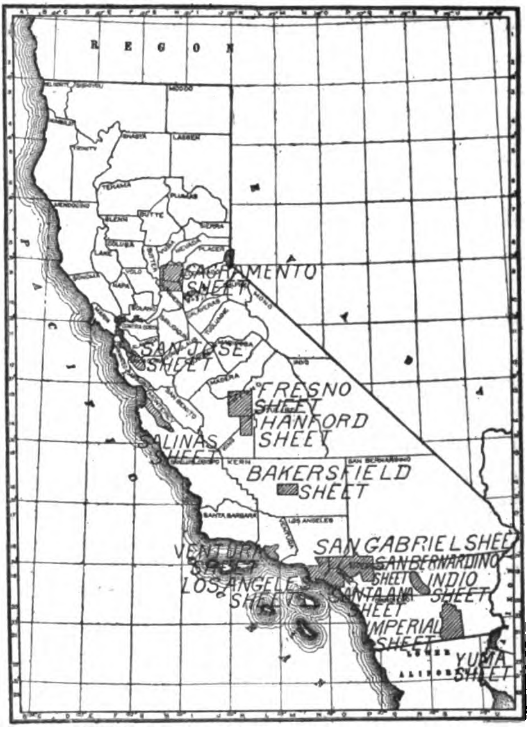

FIG. 42.—Sketch map showing location of the Yuma area, Arizona-California.

Including the previous survey of 99 square miles, the Yuma area contains 217,408 acres, or about 340 square miles.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

Below Yuma, in the Yuma Valley, quite a little progress has been made in agriculture, crops having been grown for some years, and the history of settlement and agricultural development of this area is given in some detail in the report made upon the work done in this valley in the spring of 1902 and published in the report on the field operations of the Bureau of Soils for that year.

On the valley lands covered by the present survey there is no irrigation of any extent. Only a little cultivation has been done, and in these instances crops have been grown wholly from the moisture left in the soil from the overflow. In this way small patches of corn, pumpkins, and other summer crops are being produced. Most of this cultivation has been done on the Indian reservation opposite Yuma on the California side of the river. A good many years ago there were a few alfalfa and grain farms along the Gila River toward the eastern end of the area surveyed. Water for irrigating these crops was taken from the Gila River by means of small ditches, but in 1891 the ditches were destroyed by flood, and since that time the farms have been abandoned.

On the mesa land, about a mile southwest of Yuma, there is an area of about 80 acres devoted to oranges, lemons, grape fruit, figs, grapes, and a few other deciduous fruits, water for irrigation being pumped from the Colorado River. Quite a few vegetables have also been grown on the same farm, which are ready for a very early market, and hence bring a fancy price. The fruit trees are in bearing and seem to do well. Oranges of good quality were being gathered in January, 1904. The orchard has not been well cared for, which gives it a sort of unkempt appearance. Better care would certainly greatly improve the quality of the fruit as well as the health of the trees. The experience gained, however, has been sufficient to demonstrate that citrus fruits can be made a success on the mesa lands.

CLIMATE.

The Yuma area is in an extremely arid belt. The rainfall is not only very light, but its time of occurrence is also very irregular, so that upon all lands not overflowed irrigation is the only source of moisture to be depended upon for all cultivated crops. The summers are long and very hot, while the winters can hardly be called such at all. The maximum daily temperature in summer often ranges from 112° to 120° for weeks at a time, although the nights are usually cool enough to be comfortable. The winter nights, especially in the valley, are occasionally quite cold, ice often forming, but the days are live almost entirely out of doors, and suffer ve account of the weather. The mesa land, situ east of the valley lands along the river, has a mate from these valley lands. Upon this mes cold, and frost occurs less often. Here orange thrive, and suffer but little from cold weather.

Appended is a table compiled from record reau, showing the temperature and rainfall a other station in the area surveyed.

Normal monthly and annual temperature a

Month.	Yuma.		Montl
	Temperature.	Precipitation.	
	° *F.*	*Inches.*	
January	53.9	0.42	August
February	59.0	.51	September
March	65.1	.26	October
April	70.5	.07	November
May	77.8	.04	December
June	84.8	.00	Year
July	91.5	.14	

PHYSIOGRAPHY AND GEOLOG

The valley lands immediately along the riv the local occurrence of sand dunes, gullies, beds. These minor departures from grade i make leveling for irrigation quite expensi instances are they sufficient to make economic Skirting the valley lands on the east and so mesa lands which for the most part is comp mesa proper rises from 65 to 70 feet as an a valley lands. In the eastern part of the a quite a little mesa land that is but a few feet

The valley is formed almost wholly from left by the river as it has cut through the me The general formation is a great bed of san stratified with layers of finer material deposi has shifted its course from one side of the Except immediately along the foothills or me valley, the soils are not traceable to the rock the Colorado has a great number of tributari territory, and any one of these tributaries may at different flood seasons for the sediment carried by this lower part of the stream. The mesa is an old coastal plain, and that part of it mapped was once near the beach. It is all comparatively level, except for a strip about one-fourth of a mile wide along the bluff line which erosion has made quite rough.

The area is dissected by the Colorado River, the largest stream in the Southwest. The Gila River, an intermittent stream, flows into the Colorado at the town of Yuma.

Gila Valley forms the greater part of the bottom lands of the valley proper. Much of these lands is overflowed.

The northern part of the area is bounded on each side by granitic hills, while farther to the south the eastern side of the mesa land mapped is bounded by only a slight rise in the plain, the soils remaining the same to the eastward. Colorado River, where it forms the boundary between Lower California and Arizona, bounds the area on the west.

SOILS.

The soils of the area mapped are distinctly of two series—valley soils proper, or those alluvial soils formed from deposits of the Colorado and Gila rivers, and mesa soils, or those which formed the coastal plain along the Gulf when it extended much farther inland than at present. The river valleys are underlain at varying depths by sand, which makes the drainage in the soil itself very good. This sand is in places quite coarse, but the greater part is medium to fine in texture and has the characteristics of quicksand. When this fine sand is found on the surface it forms the Imperial fine sandy loam.

In the valley the following six types of soil were recognized and mapped: Imperial sand, Imperial sandy loam, Imperial fine sandy loam, Imperial silt loam, Imperial loam, and Salt River adobe. The mesa is made up almost entirely of one type of soil, a rather coarse sand, that in places is cemented together by a small amount of lime. Along the washes in the low mesa land to the east of the northern part of the area is found a very loose, incoherent, gravelly sand which was mapped as Fresno gravelly sand.

Along the edge of the mesa there is a strip of land of varying width which, because of its roughness, was mapped as Rough stony land. Other small areas throughout the district that were evidently too rough to be leveled for irrigation were also thrown in this class so that, in all, the soil map accompanying this report shows in colors nine distinct soil types.

The following table gives the actual and relative extent of each of these types:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Yuma sand	94,400	43.5	Rough stony land	6,380	2.9
Imperial fine sandy loam	38,848	17.8	Fresno gravelly sand	4,160	1.9
Imperial loam	24,384	11.2	Salt River adobe	4,036	1.9
Imperial sandy loam	18,496	8.5	Total	217,408	....
Imperial sand	14,272	6.4			
Imperial silt loam	12,672	5.9			

IMPERIAL SAND.

The Imperial sand occupies about 22 square miles, or 6.4 per cent of the area mapped. It is a loose, incoherent, reddish-brown fine sand, usually 5 or 6 feet or more in depth. However, where it occurs in places near the mesa it is but 3 or 4 feet in depth, and is underlain by a sandy loam or loam, the heavier material representing the deposit from the river when the overflow reached to the mesa.

This soil is found in rather large areas throughout the valleys of the Gila and Colorado. Where it has been deposited by the rivers, it is made up of the largest particles which they carry. Areas along the mesa have been formed by the washing down of sand from the mesa upon the valley below. In nearly all cases the areas show some minor surface irregularities, such as dunes or washes, caused, respectively, by the wind or overflow waters acting upon its incoherent soil particles.

The Imperial sand is in all cases of such texture as to be well drained, water passing through it very rapidly. All areas above present overflow are well drained at present, but some of the low-lying areas along the river now subject to overflow have the water table close enough to the surface to make artificial drainage desirable for the growing of deep-rooted crops.

Very little of the Imperial sand now carries sufficient alkali to interfere with the growing of any of the ordinary crops. Along the mesa lands, however, where the subsoil at 3 or 4 feet is rather heavy, there is now in places quite a high percentage of alkali in the subsoil. This, however, with careful irrigation, should be leached out, and should prove of very little moment so far as its effects on growing crops are concerned.

None of this soil has been cultivated in the part of the district mapped in this survey, but below Yuma, along the Colorado River, quite large tracts have been used for some years in the growing of alfalfa, which crop does remarkably well. Barley, wheat, melons, vines, deciduous fruits, berries, and all truck crops should also do well. It is generally believed that the valley proper is too cold to grow citrus fruits, but if experience should demonstrate that these trees can withstand the low temperatures sometimes experienced in the valley, then the Imperial sand, because of its freedom from alkali and ease of cultivation, should prove to be well adapted to these fruits.

The following table gives the results of mechanical analysis of a sample of this soil type:

Mechanical analysis of Imperial sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10280	1st 40 sec. 12, T. 7 S., R. 22 W.	Fine sand, 0 to 72 inches	0.00	Tr.	1.20	42.20	38.00	15.00	3.58

IMPERIAL SANDY LOAM.

The Imperial sandy loam is a loose, friable, reddish-brown sandy loam of good texture. It will be easy to cultivate, and will require but little cultivation to maintain surface mulch and good tilth. It is usually underlain by sand of the same texture as the Imperial sand at a depth of from 3 to 4 feet, but in some instances there is an intervening stratum of loam 2 or 3 feet in thickness. The sand subsoil extends to undetermined depths.

In the area mapped the Imperial sandy loam is found chiefly in the Gila Valley east of Yuma, although small areas occur elsewhere. It is usually comparatively level, except for very small dunes about the base of small bushes or trees, but on the south side of the Gila River there is a district that is quite rough. This roughness was caused by the scouring and washing of the Gila River during the flood of 1891, at which time much country was overflowed that is not subject to ordinary annual overflows, this flood being the only one to cover these lands within the memory of the oldest inhabitants. Some of this land will be expensive to level, and can be brought under cultivation only after a considerable outlay of money.

Being underlain by sand at a few feet at most, all this soil is well drained, and only in exceptional cases should crops ever suffer on account of poor drainage. A canal carried through or just above low-lying areas might swamp a portion of it, but in such cases a few drains would be sufficient to carry off all surplus water and permanently to insure good drainage. The soil has been formed principally by a direct deposition of sediment from the rivers, but along the mesa areas are formed by an admixture of sand washed in from the mesa and smaller particles deposited from the river.

loam contains alkali. When these alkali
overflow lands, they are caused by the wat
year at least, being so near the surface as to
ration of a great deal of water from the su
behind the salts contained in this water. I
an accumulation of alkali results. Along
been caused by seepage from the mesa and
the surface.

No crops are now being grown in the v
ago, before all the water from the Gila Ri
irrigation farther upstream, quite a little
river was in alfalfa and grain. The floo
ditches supplying these ranches, however,
appropriated for use above that no attempts
bring these lands under cultivation. For
tables, or almost any crop suitable to the c
good soil.

The following table gives the results o
this type:

Mechanical analyses of Imperial

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5
			P. ct.	*P.*
10272	SW. cor. 6th 40 sec. 17, T. 8 S., R. 21 W.	Sandy loam, 0 to 48 inches.	0.20	1.
10273	NE. cor. 7th 40 sec. 9, T. 8 S., R. 21 W.	Sandy loam, 0 to 60 inches.	.20	.
10274	S. cen. 5th 40 sec. 4, T. 8 S., R. 21 W.	Sandy loam, 0 to 72 inches.	3.10	6.
10271	SW. cor. 14th 40 sec. 19, T. 8 S., R. 21 W.	Loam, 0 to 48 inches....	.00	T
10279	SE. cor. 1st 40 sec. 20, T. 8 S., R. 21 W.	Loam, 0 to 72 inches....	.00	.
10278	10th 40 sec. 28, T. 8 S., R. 22 W.	Loam, 0 to 12 inches....	.00	.

IMPERIAL FINE SANDY LOA

The Imperial fine sandy loam is a fine
The particles are nearly all of uniform siz
capillary power and one through which wa

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[a] This soil was mapped under the name Gila fi
made around Yuma in 1902.

distances, but also with great rapidity. It will be easily cultivated, and will be in good tilth for a long time after each cultivation. The surface soil is from 3 to 20 feet deep, and is nearly always underlain by a coarser sand. In some instances, however, the areas of shallower soil have a stratum of heavier material between the surface covering of fine sandy loam and the sand beneath.

The Imperial fine sandy loam is found in long, narrow strips along the Colorado River and farther out in the bottoms, and in large areas in the valley between the Gila and the Colorado, and south of the Gila in its own valley. It is usually quite smooth, and will require but little leveling to prepare it for irrigation. Over most of it the greatest expense in preparing the land for cultivation will be for clearing, as it is usually covered with a dense growth of cottonwood, willow, or arrow weed. A notable exception to this, however, is the large area, strongly impregnated with alkali, situated in the joint valley of the Gila and the Colorado.

The sandy subsoil in this type insures good drainage if there be an outlet for the ground water, and with such an outlet frequent flooding will prevent a surface accumulation of alkali.

The Imperial fine sandy loam is composed of sediments deposited when the rivers spread out in their annual flood. As the river overflows its banks it is checked by timber, bushes, etc., and the coarser particles in suspension are dropped, forming this fine sandy loam, the lighter or smaller particles being carried farther inland and deposited in comparatively still water. In this way the land near the river is built up faster than that farther back, which ultimately results in the river cutting through its bank and seeking a lower bed. Thus the various areas of the Imperial fine sandy loam have been formed as the river has shifted about from channel to channel, and this is why the areas are slightly higher than the surrounding areas of loam or silt loam.

At some time nearly all the valley has had a high water table. Water moves through this soil with such rapidity that with this high water table it would quickly be filled with alkali, and nearly all the areas not now subject to annual overflow and leaching carry more or less of these injurious salts, which have been concentrated through evaporation at the surface. Where the water table has stood for some years close to the surface, and no surface flooding has taken place, an accumulation of as much as 3 per cent in the surface foot is not uncommon. A few heavy surface floodings, followed by cultivation to prevent evaporation, should greatly improve these lands, however, and, on the whole, though some areas are now shown in the "1 to 3 per cent" grade on the alkali map, this condition, as affecting the ultimate value of the land, is not a very serious one. One year's heavy flooding should suffice to reclaim the

reclaimed, provided there be drainage su
ground water. The same properties in the s
rapid accumulation of alkali will aid in its

This soil is an exceptionally good one f
the climate, and especially for alfalfa. It
excellent texture that it affords a deep ro
minimum resistance to the extension of the
tial to the perfect growth of this valuable
of its location along the bottoms, many tree
grown in very deep soil will no doubt suff
table, but for all shallow-rooted vines, fr
better soil is found in the valley.

The following table gives the results of
typical samples of this soil:

Mechanical analyses of Imperial fine

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.
			P. ct.	*P. ct*
10258	¼ N. of SE. cor. sec. 10, T. 16 S., R. 23 W.	Fine sandy loam, 0 to 72 inches.	0.00	0.2
10247	NW. cor. 4th 40 sec. 26, T. 16 S., R. 22 W.	Fine sandy loam, 0 to 72 inches.	.00	.1
10248	¼ S. of NW. cor. sec. 31, T. 6 S., R. 21 W.	Fine sandy loam, 0 to 72 inches.	.10	.4
10240	NW. cor. 2d 40 sec. 6, T. 7 S., R. 21 W.	Silty loam, 0 to 36 inches.	.00	Tr.
10236	¼ SW. of NE. cor. sec. 8, T. 8 S., R. 22 W.	Silty loam, 0 to 60 inches.	Tr.	.2
10254	¼ NW. of SE. cor. sec. 16, T. 8 S., R. 22 W.	Silty loam, 0 to 72 inches.	.00	.0
10225	NE. cor. 5th 40 sec. 20, T. 8 S., R. 22 W.	Medium sand, 36 to 72 inches.	.00	.7
10233	Subsoil of 10232	Sandy loam, 48 to 72 inches.	7.18	11.3
10229	Subsoil of 10228	Brown loam, 36 to 72 inches.	.00	.0

IMPERIAL SILT LOAM.[a]

The Imperial silt loam is composed of the
finer than that forming the Imperial fine sa
sandy loam, it consists of particles of very un

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[a] This soil mapped under the name Santiago si
around Yuma in 1902.

underlain by sand, but in rare instances by loam or even clay. It also is found principally along the Gila or Colorado River, on lands at present overflowed, where it occurs only as a surface covering for the other soils. Any shifting or changing in the river channels would no doubt change the boundaries of the areas outlined. It occupies low places, such as the beds of former river channels or large depressions where water may drain off, but where in times of overflow it has very little, if any, current. The surface of the various areas is always comparatively level, but usually all this type of soil is below the surrounding lighter soils, and as the areas are, as a rule, long, narrow strips, some expense will be necessary to bring them under irrigation.

The silt loam is and will continue to be the most poorly drained type in the area. Over most of the valley the water table at the time of examination was not close enough to the surface to injure grain or other comparatively shallow-rooted crops, but if the country were leveed, as would have to be done to grow any but overflow crops, this soil would be the first to suffer in time of high water in the river from the rising water table. Being underlain by a lighter sandy material, the water would rise rapidly in the subsoil, while the low-lying position of the areas would make them the first to become swampy.

Like most of the soils of the valley, this type is directly traceable to the sediment of the Colorado or Gila River. Both rivers carry a great amount of sediment in overflow times, much of which is deposited upon the bottom lands as soil. The silt loam is the sediment deposited after the moving waters have been robbed of their fine sand to form the Imperial fine sandy loam.

When it occurs in large areas the Imperial silt loam is often free from alkali, but the long, narrow strips often carry appreciable quantities, and sometimes quite a high percentage. This condition is caused by the high water table, either immediately after overflow or throughout the year.

In the areas mapped almost no crops have been grown on this soil type, but when the coarse sand does not approach too near the surface it should prove an excellent soil for all summer overflow crops, such as Kafir, Egyptian, and Indian corn, Milo maize, millet, sorghum, etc. Garden vegetables, melons, and pumpkins could all be grown from this overflow. Much of this soil now lying idle and supporting only useless willows might thus be made to grow valuable crops from the overflow alone. When diked and subjected to perennial irrigation. with drainage to carry off the surplus of ground water during high stages of the river, almost any crop suitable to the climate could be grown. It is a very rich soil and easily cultivated, so that it lends itself readily to the growing of special crops under a high state of cultivation. It is on a similar soil in Orange County, Cal., that most of the celery for which that county is noted is grown, while it is one of the most important bean soils of Ventura County, in the same State.[a]

The following table gives mechanical analyses of this type:

Mechanical analyses of Imperial silt loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
10285	S. cen. 9th 40 sec. 8, T. 8 S., R 21 W.	Heavy silty loam, 0 to 12 inches.	0.26	0.60	0.52	4.68	22.40	48.28	23.42
10289	SE. cor. 12th 40 sec. 18, T. 7 S., R. 22 W.	Silty loam, 0 to 36 inches.	.00	.24	.20	1.54	8.12	63.20	26.68
10290	NW. cor. 1st 40 sec. 26, T. 8 S., R. 23 W.	Silty loam, 0 to 72 inches.	.00	.00	.00	3.10	12.90	54.80	29.40
10283	Cen. SW. ¼ 14th 40 sec. 6, T. 8 S., R. 22 W.	Heavy silty loam, 0 to 18 inches.	.00	.58	.60	2.40	4.40	54.60	37.30
10287	16th 40 sec. 12, T. 7 S., R. 22 W.	Clay loam, 0 to 14 inches.	Tr.	.30	.34	1.92	3.64	53.90	39.80
10284	Subsoil of 10283	Sand, 18 to 72 inches	.22	3.70	22.90	58.90	11.74	1.72	.76
10286	Subsoil of 10285	Fine sand, 36 to 72 inches.	.00	.18	.78	50.90	34.46	10.40	3.00

IMPERIAL LOAM.

The Imperial loam is a sticky, plastic, rather heavy, difficultly cultivable, chocolate-brown loam, composed of finely divided particles of mineral matter, and often a liberal addition of organic matter. In the districts mapped this season the surface soil ranges from 3 to 6 feet deep, and is usually underlain by a sand, although in some cases clay is found between the loam and the sand beneath.

The Imperial loam is pretty well distributed throughout the bottom lands, but the largest areas are on the south side of the Gila River, along and below the mesa line that divides the high plateau back of Yuma from the bottoms proper. It is nearly always level, and requires but little work to prepare for irrigation. Most of it is above present overflow, and for this reason is quite well drained.

This soil, too, owes its existence to the Colorado and Gila rivers. It is the same soil found so extensively below Yuma on lands at present overflowed, and is the principal soil of the Imperial country in California. All these areas have been deposited directly from the waters of the rivers.

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[a] See Field Operations of the Bureau of Soils, 1900.

Nearly all the Imperial loam contains alkali. The percentage varies from about 0.20 per cent to more than 3 per cent. Because of its present condition as regards these injurious salts, its depth, and the frequent occurrence of the heavy subsoil, injury to crops from alkali is more to be feared in this soil than in any other in the area. Under careful management, however, it should prove a very productive and valuable soil for the cereals and such summer annuals as Kafir, Egyptian, and Indian corn, millet, sorghum, and in fact all crops not requiring intertillage. Alfalfa does well if not pastured, but pasturing tends so to pack the soil as soon to kill the plants.

The following table gives the results of mechanical analyses of the soil and subsoil of this type:

Mechanical analyses of Imperial loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10264	¼ NW. of SE. cor. sec. 35, T. 8 S., R. 22 W.	Loam, 0 to 24 inches...	0.16	1.68	3.06	15.30	19.26	22.90	37.66
10263	SW. cor. 14th 40 sec. 32, T. 8 S., R. 22 W.	Brown friable clay loam, 0 to 72 inches.	.00	.20	.36	2.48	11.60	42.60	42.66
10261	3d 40 sec. 34, T. 8 S., R. 22 W.	Heavy clay loam, 48 to 72 inches.	.00	.00	.08	.48	4.96	61.26	33.20

SALT RIVER ADOBE.

The Salt River adobe is a very heavy dark-brown to black clay loam, from 1 to 3 feet deep, sticky, plastic, and difficult to cultivate, and underlain by fine sandy loam or fine sand. When the water subsides and the surface is exposed to the hot sun, great cracks, 2 to 4 inches wide, cut the surface in every direction, often extending into the soil to a depth of 2 feet or more. These cracks divide the soil into blocks from 1 to 2 feet in diameter. As the soil dries further and is subjected to weathering agencies, these blocks weather down into rounded elevations with numberless small cracks crossing them in all directions.

Only very small areas of this soil are found in the Yuma area, and these are nearly all on overflowed land in the immediate vicininty of Yuma or regions influenced by sediment of the Gila. The surface is

As a rule this soil occurs along the sloughs an
water may often be found several months afte
Colorado. It is composed of fine alluvial sed
found principally in that part of the valley af
the same soil is found along its tributaries fa
it is fair to presume it is here built up fron
stream.

Only part of this soil contains alkali, but if
nual overflow its low-lying position and con
would soon result in such an accumulation o
that crops could not be grown. Irrigation on
would in most cases soon swamp it. No crops
it, but with adequate drainage precautions, co
saccharine sorghums, cereals, and other annu
intertillage would do well. Its heavy, sticky
to make the growing of crops requiring intertil

The following table gives the results of mec
soil and subsoil of this type:

Mechanical analyses of Salt River

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.
			P. ct.	*P. ct.*
10291	S. of cen. 12th 40, sec. 23, T. 16 S., R. 22 E.	Clay to clay loam, 0 to 42 inches.	Tr.	0.12
10292	Subsoil of 10291	Yellow fine sand, 42 to 72 inches.	.00	.00

YUMA SAND.

The Yuma sand is a rather compact coarse
taining sufficient finer material to give it a sli
When dry the soil has the appearance of san
as, for instance, at Blaisdell Heights, it becom
It is underlain at a depth of from 2 to 6
layers in which the soil particles are slightly
material being calcium carbonate, nodules of
in the subsoil. A little gravel is encountere
more noticeable near the margin of the me

out of the finer material has left behind the gravel originally distributed through several feet of material. The subsoil to a great depth is of the same sandy nature as the surface. In a well recently bored on the mesa about 2 miles south of Yuma the same sandy material was found to extend to a depth of 70 feet, where clay was encountered. Along the ridge of the mesa, strata of heavier material from 1 to 3 or 4 feet thick outcrop in various places.

The Yuma sand is found wholly on the mesa lands south of the Gila Valley and east of the Colorado Valley proper below Yuma. It is, in general, practically level and smooth, but where the texture is finer small dunes are found. These are rather low and broad, and will be neither difficult nor expensive to level for irrigation. The soil will always be well drained.

This mesa land, where the railroad cut at Yuma exposes it to a depth of 30 to 50 feet, and along the bluff skirting the valley, shows imperfect stratification, which might be due either to action along an old beach line or to delta deposits. The large uniform tract of coarse sandy soil, however, indicates a deposit in water near a beach line, so that in all likelihood this soil was formed when the Gulf extended several miles above Yuma.

Nearly all the mesa soil contains a small amount of alkali, ranging from a trace to nearly 0.20 per cent. The open, porous nature of the soil and its high-lying position, however, make this amount of no danger, provided occasional floodings be employed to wash the salts down into the subdrainage waters.

Oranges and other citrus fruits, figs, grapes, garden vegetables, and melons have been grown on this soil at the Blaisdell farm, south of Yuma, and all with success. The orange grove does not compare with the southern California groves, either in general appearance or quality of fruit, but such could hardly be expected from the scant care given it. The orchard has a general unkempt appearance and certainly has not been given proper treatment. Under more careful and scientific management oranges should do well. Lemons might do well farther out on the mesa, but near the valley frosts would possibly injure them. During the winter of 1901–2, as the writer observed, nearly all the leaves of the orange grove had been so badly frosted that they were dropping. Vegetables and early fruits, berries, melons, etc., should be a paying crop on these lands, as the mesa is so much warmer than the valley that they ripen earlier, and all crops are a month or so earlier here than in southern California. Alfalfa might do well also, but other crops will no doubt prove more valuable.

typical samples of the Yuma sand:

Mechanical analyses of Yuma s

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.
			P. ct.	*P. ct.*
10220	Cen. sec. 36, T. 11 S., R. 23 W.	Red medium sand, 0 to 12 inches.	0.20	5.86
10223	NW. cor. of 12th 40 sec. 11, T. 9 S., R. 23 W.	Fine sand, 0 to 72 inches.	.70	1.90
10221	1/16 W. of cen. sec. 14, T. 9 S., R. 23 W.	Medium sand, 0 to 48 inches.	3.00	13.88

FRESNO GRAVELLY SAND.

The Fresno gravelly sand is a loose, incoher
in depth, containing gravel. The interstitial
a light-brown to an almost pure-white quartz
range in size from coarse sand to 3 or 4 inches

This type of soil is found along the eastern
of Gila River to the northern limits of the
western part of the area that is flanked by hil
of the small washes and forming a part of
bottom lands proper. It is generally of fair
may have a rather steep slope. Nearly all
with not too great an expenditure of money,
carried above it. The greater part of it, ho
and to run a canal at such a level as would n
ient would mean great expense for excavation.

This soil is the wash from hills along the
formed by deposition from small streams o
heavy downpours acting along the sides of the

The Fresno gravelly sand is all well draine
salts. No crops have been grown, but upon
grapes, and other deep-rooted trees should d
and the other common field crops might do fai
nature of the soil would require the use of
render their production of doubtful profit.
especially adapted to the fruits suited to the cl

The following table gives the results of a mechanical analysis of a typical sample of this soil:

Mechanical analysis of Fresno gravelly sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10222	5th 40 sec. 8, T. 7 S., R. 21 W.	Coarse sand, 0 to 72 inches.	2.40	13.50	26.60	33.88	15.82	4.90	2.80

ROUGH STONY LAND.

The rough, uncultivable portion of the area includes all very rough lands surrounded by cultivable soil. The soil may vary in texture from bare rock outcrop to sand. Several small hills of coarsely crystalline granite on the mesa southeast of Yuma, other hills of a sandy loam east of the northern part of the area, and the rough, weathered bluff line along the mesa constitute about all the lands too rough for cultivation. Of these the mesa line may, under intensive cultivation, eventually become valuable as terraced tree lands. The soil along this bluff is a gravelly sandy loam, in some cases carrying a low percentage of alkali.

HARDPAN.

The soil of the mesa land above Yuma contains, at a depth ranging from 2 to 6 feet, successive layers of material that somewhat resembles hardpan. These layers are caused by a slight cementing of the soil particles with calcium carbonate. Calcium carbonate nodules also occur in some of these strata, and where this is the case the material somewhat resembles the hardpan of the Salt River Valley, though much less coherent and not so thick in any one stratum. In fact, these strata are not a hardpan in the true sense of the word and they should entirely disappear upon irrigation.

If it were not for the abundance of gypsum in the irrigation water of the river the breaking up of this so-called hardpan would no doubt result in the formation of sodium carbonate, or black alkali, which, in the growing of fruits with furrow irrigation, would no doubt accumulate at the surface. The presence of gypsum, however, will prevent the black alkali existing as such for any length of time.

In the bottom lands there is no trace of any hardpan, nor of any slightly indurated strata, such as those described as occurring in the uplands.

WATER SUPPLY FOR IRRIGATION.

None of the lands covered by the present survey are irrigated, except the small tract on Blaisdell Heights, water for which is pumped from the Colorado. All of the water for irrigation of the area examined will come from the Colorado, the Gila being an intermittent stream and hardly to be depended upon as a source of supply. The Colorado here is a large stream of muddy, silt-laden water. It has its source in high, snow-clad mountains, so that the maximum amount of water comes down during the hot summer months. From June to August the Colorado is a raging torrent, overflowing its banks and cutting and changing its channel. The overflow area in the tract surveyed begins only a few miles above Yuma and gradually widens till near the point where the Colorado leaves the United States. All the bottom lands proper are overflowed. During these months vast quantities of water flow into the Gulf and are lost. The normal flow of the river, as shown by official measurements, will, no doubt, suffice to irrigate all lands of this lower delta part of the country if no great appropriations take place above. The greatest flow comes during the season when the greatest amount of water is needed, so that if the water is used for these lands alone little or no storage will be necessary.

The quality of this irrigation water is good. A number of chemical analyses show that on an average it contains about 87 parts of soluble matter per 100,000 of water, and about 31 per cent of the total salts is gypsum, which is beneficial to crops. No fear need be had in using such water if ordinary precautions be taken to prevent continuous subirrigation, and an occasional flooding given those lands not flooded in the ordinary course of irrigation. The water of the Colorado contains a great deal of fertility, or plant food, both in suspension and in solution, as shown by a series of analyses extending through the year, made by Prof. R. H. Forbes, director of the Arizona experiment station. These analyses show the water of this river to be as rich, if not richer, than that of the world-famed Nile. If a system of canals can be made upon such a grade that the sediment will reach the cultivated fields, the productivity of the soil should be practically inexhaustible, making possible the almost continuous growing of any strong feeding crop without diminution in yield.

The following table, showing the composition of the waters of the

Colorado River, is taken from Bulletin No. 44 of the Arizona agricultural experiment station, by Prof. R. H. Forbes:

Composition of the waters of the Colorado River.

PARTIAL ANALYSIS.

Samples taken at Yuma, Ariz.	Low winter waters, Jan. 10–Mar. 26, 1900.	Rising summer waters due to melting snows, etc., Mar. 27–Apr. 31.	High summer waters due to melting snows, etc., May 1–June 29.	Low waters after melting of snows, June 30–Aug. 26.	Summer waters affected by local floods, Aug. 27–Oct. 1.	Summer flood waters from Arizona, Oct. 2–Nov. 19.	Low winter waters, Nov. 20–Jan. 24, 1901.
Silt, per cent by weight	0.0625	0.1122	0.374	0.123	0.278	0.963	0.1513
Soluble solids, parts in 100,000	92.95	67.4	32.16	36.1	71.4	104.5	87.1
Containing:							
Chlorine, stated as common salt, NaCl	33.76	22.1	7.4	11.45	25.9	28.2	30.4
Alkalinity, stated as sodium carbonate, Na_2CO_3	....	....	....	....	....	....	....
Permanent hardness, stated as calcium sulphate, $CaSO_4$	14.03	16.28	6.06	5.08	11.22	27.35	12.22
Nitrogen, parts in 100,000:							
Total nitrogen in silt and water	1.52	1.71	2.43	1.25	2.71	7.33	2.26
Nitrogen in nitrates	1.15	.66	.62	.64	.67	.99	.80
Nitrogen in nitrites	Traces.	Traces.	Traces.	Traces.	Traces.	Traces.	Traces.

COMPLETE ANALYSIS OF SOLUBLE SALTS, STATED BY IONS. PARTS IN 100,000 OF WATER.

Sodium, Na	18.98	15.34	5.49	7.63	14.63	18.17	15.95
Potassium, K	1.07	2.08	1.02	1.29	1.77	2.13	1.22
Calcium, Ca	7.49	4.86	4.23	4.57	7.66	12.45	9.17
Magnesium, Mg	3.14	2.00	1.15	1.21	2.21	2.80	2.80
Chlorine, Cl	20.50	13.88	4.48	6.91	15.76	17.45	18.06
Sulphuric, SO_4	26.10	19.38	7.16	7.62	19.68	35.64	23.81
Carbonic, CO_3	[illegible]	8.36	7.21	7.73	9.95	12.18	10.66
Silicic, SiO_3	4.59	2.10	2.13	3.28	2.34	2.23	2.08

COMPLETE ANALYSIS OF SOLUBLE SALTS, CALCULATED TO COMPOUNDS. PARTS IN 100,000 OF WATER.

Sodium carbonate, Na_2CO_3	....	....	....	....	....	....	....
Sodium silicate, Na_2SiO_3	7.36	3.37	3.41	5.26	3.75	3.58	3.34
Sodium chloride, NaCl	33.83	22.90	7.40	11.40	26.00	28.80	29.80
Sodium sulphate, Na_2SO_4	8.89	15.58	3.97	3.58	9.19	16.89	9.10
Potassium sulphate, K_2SO_4	2.38	4.64	2.28	2.87	3.94	4.75	2.72
Magnesium sulphate, $MgSO_4$	1.01	....	....	....	....	....	....
Magnesium carbonate, $MgCO_3$	10.29	7.00	4.03	4.24	7,74	9.80	9.80
Calcium sulphate, $CaSo_4$	25.46	8.91	4.56	5.13	16.01	30.60	22.59
Calcium carbonate, $CaCO_3$	....	5.60	7.22	7.65	7.88	8.63	6.10

UNDERGROUND AND SEEPAGE WATERS.

All of the valley lands mapped have water underlying at a depth of from 3 to 25 feet. Seldom is the depth as great as 25 feet, except on the higher portions immediately along the mesa. This underground water varies greatly in character, ranging from practically the same composition as the river water to strongly brackish. This variance in amount of soluble matter is due to the spotted nature of the soil, salts in the water being in nearly all cases traceable to the alkaline areas of soil. By sinking a few prospect holes, which can be rapidly done, good water for domestic use can be had on nearly any 40-acre tract in the bottoms.

During the period covered by the survey (October 1 to December 31, 1903) very little of the land not subject to overflow or surrounded by overflow lands had water less than 10 feet from the surface. On much of the overflowed lands, however, the water was within 3 or 4 feet of the surface. In order to control the irrigation these lands would have to be diked, which, during the overflow season, would raise the height of the water in the confined stream and thus subject this ground water to a greater head than it now has, and raise it even nearer the surface. For these overflowed lands, if diked, and for some of the alkali lands a drainage system is necessary.

ALKALI IN SOILS.

A considerable part of the lands surveyed carries an appreciable quantity of alkali. The lands so affected are found principally in three characteristic situations: Along the outer edge of the area subject to annual overflow; on the high ridges within the overflowed district, but not actually covered by water; and in a narrow strip immediately below the mesa. Other isolated patches of alkali land occur, but the above-mentioned areas include about all those of any magnitude.

The alkali found just above overflow and on the small areas surrounded by water, but not actually covered, comes principally from the salts carried in solution by the water, but partly from the decomposition of the soil itself. Its accumulation is all directly due to the high water table maintained by the standing of water upon the near-by flooded area. Evaporation takes place from the surface very rapidly in this hot country, and when the water approaches so close to the surface that capillarity makes connection between the water and the surface the amount evaporated is great, the salts contained in the water being left behind largely at the surface, the point of greatest evaporation. The rainfall here is inappreciable, so that there is nothing to wash this accumulation down into the subdrainage, unless artificial watering occur, as in flooding in irrigation, or by natural overflow covering the surface. After successive years of this evaporation enough salt is accumulated to injure or prevent the growth of useful plants.

Much of the lands now subjected to overflow has a high water table the year around, so that during the interval between floods there is quite an accumulation of salts at the surface. Each successive overflow washes the salt out and leaves the soil, immediately after the subsidence of the water, practically free from injurious salts. Thus these lands may be said to be intermittently alkaline, and as long as the present order of things is maintained their condition will not be very bad.

The alkali at the foot of the mesa has been caused by the subirrigation of these areas by the slight seepage from the mesa lands, the difference in elevation between the mesa and the bottoms below being from 65 to 80 feet. This mesa soil all contains a small quantity of alkali, so that water seepage from it would be slightly impregnated. Its evaporation from the surface would leave salts behind and account for the accumulation here just as the accumulation has occurred near the overflow lands.

A great number of analyses have been made of the soils found upon the delta of the Colorado and the valleys along this river, to determine the chemical composition of the soluble salts found. Appended are a number of analyses made in the laboratory of the Bureau of Soils of the valley soils of the Colorado River.

Chemical analyses of samples of alkali soils, Yuma area, Arizona.

CONSTITUENTS—IONS.

Laboratory No.	Per cent soluble salts.	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Sulphuric acid (SO_4).	Chlorine (Cl).	Bicarbonic acid (HCO_3).	Carbonic acid (CO_3).
10221......	0.76	1.31	1.05	26.25	5.77	21.52	22.05	23.05	....
10223......	.48	9.48	3.44	12.50	5.17	34.06	12.07	23.28	....
10224......	.68	2.34	5.26	18.72	2.04	42.98	4.09	24.57	....
10226......	1.09	3.85	.36	26.22	5.87	14.68	33.61	15.41	....
10227......	.93	....	.64	29.68	2.15	48.61	6.02	12.90	....
10228......	3.57	4.14	.89	30.80	1.68	8.84	50.46	3.19	....
10229......	8.00	1.06	.79	29.57	6.39	18.04	39.36	4.79	....
10232......	3.51	3.87	1.59	25.95	5.81	18.56	46.49	2.73	....
10233......	4.24	8.45	1.79	22.48	5.38	5.28	53.84	2.83	....
10236......	12.96	7.45	2.70	25.11	1.86	4.74	57.59	.55	....
10238......	1 68	3.33	3 56	23.32	4.87	22.00	36.86	6.06	....
10239......	2.63	11.47	3.79	17.16	2.12	15.18	45.96	4.32	....
10240......	.59	4.73	4.39	15.88	7.43	29.73	7.57	20.27	....
10242......	5.31	6.29	.18	26.19	2.63	36.40	26.51	1.80	....
10244......	.53	8.33	5.30	12.50	2.65	40.92	10.60	19.70	....
10245......	.53	8.23	5.24	11.99	3.74	40.46	7.86	22.48	....
10248......	.98	3.49	1.23	23.21	6.57	35.93	17.25	12.32	....
10249......	3.21	4.23	2 53	23.49	7.35	12.08	47.38	2.99	....
10250......	.32	8.80	5.08	13.21	2 51	27.07	13.20	30.18	....
10251......	.93	8.17	4.30	10.33	7.52	35.26	24.10	10.32	....

Chemical analyses of samples of alkali soils, Yuma area, Arizona—Continued.

CONSTITUENTS—IONS—Continued.

Laboratory No.	Per cent soluble salts.	Calcium (Ca).	Magnesium (Mg).	Sodium (Na).	Potassium (K).	Sulphuric acid (SO_4).	Chlorine (Cl).	Bicarbonic acid (HCO_3).	Carbonic acid (CO_3).
10253......	2.19	3.20	1.46	26.81	6.49	11.53	45.02	5.49	....
10254......	3.86	4.25	2.23	24.94	6.74	8.65	50.70	2.49	....
10255......	2.09	3.06	.48	24.64	11.61	11.32	43.14	5.75	....
10256......	1.07	....	1.49	27.99	8.95	13.80	36.77	6.71	4.29
10257......	1.27	4.39	1.25	26.85	3.45	14.44	39.73	9.89	....
10260......	4.02	2.73	1.19	30.54	3.77	8.50	51.48	1.79	....
10261......	2.99	2.07	.53	30.28	4.28	22.95	36.68	3.21	....
10262......	2.42	7.59	1.23	23.68	4.29	15.18	44.07	3.96	....
10263......	1.80	....	1.11	30.00	7.11	9.66	43.79	8.33	....
10264......	3.67	15.99	3.04	14.65	1.90	6.52	55.13	2.77	....
10265......	2.21	1.99	1.08	29.15	5.15	15.75	42.00	4.88	....
10267......	1.84	15.34	3.04	8.82	9.46	10.23	47.46	5.65	....
10268......	1.98	1.51	.80	29.87	3.54	29.75	28.46	6.07	....
10269......	1.00	.80	.80	26.25	10.42	13.02	36.69	12.02	....
10270......	2.71	2.07	.59	26.19	7.68	33.62	24.98	4.87	....
10273......	1.54	10.36	3.10	15.18	7.38	14.87	41.84	7.77	....
10274......	1.08	7.57	2.03	20.71	5.91	13.30	41.61	8.87	....
10275......	4.85	6.62	1.79	25.49	2.94	15.09	47.25	.82	....
10277......	2.92	.82	.41	33.24	3.55	12.66	45.22	4.10	....
10279......	1.12	6.61	2.50	18.61	6.79	31.49	25.42	8.58	....
10285......	.93	6.86	1.50	19.53	6.86	22.76	27.04	15.45	....
10289......	.39	....	5.61	18.38	4.59	23.47	5.10	42.85	....
10290......	.73	3.85	3.30	21.24	4.40	13.50	26.98	26.73	....

CONSTITUENTS—CONVENTIONAL COMBINATIONS.

Laboratory No.	Calcium sulphate ($CaSO_4$).	Calcium chloride ($CaCl_2$).	Magnesium sulphate ($MgSO_4$).	Magnesium chloride ($MgCl_2$).	Potassium chloride (KCl).	Sodium chloride (NaCl).	Sodium sulphate (Na_2SO_4)	Sodium bicarbonate ($NaHCO_3$)	Sodium carbonate (Na_2CO_3)
10221.....	4.46	....	4.98	....	11.03	27.83	21.25	30.45	....
10223.....	32.32	....	13.79	3.44	9.92	7.76	....	32.77	....
10224.....	7.89	....	26.02	....	3.80	3.80	24.57	33.92	....
10226.....	13.03	....	1.65	....	11.19	46.62	6.23	21.28	....
10227.....	....	....	3.22	....	4.08	6.66	67.98	18.06	....
10228.....	12.54	1.23	....	3.52	3.19	75.10	....	4.42	....
10229.....	3.66	....	3.86	....	12.25	55.26	18.38	6.59	....
10232.....	13.16	....	5.36	1.99	11.06	64.67	....	3.76	....
10233.....	7.50	17.24	....	7.03	10.20	54.07	....	3.96	....
10236.....	6.71	15.15	....	10.59	3.55	63.25	....	.75	....
10238.....	11.29	....	17.60	....	9.39	53.40	....	8.32	....
10239.....	21.49	14.28	....	14.88	4.02	39.33	....	6.00	....
10240.....	15.88	....	21.62	....	14.19	17.91	2.02	28.38	....
10242.....	21.38	....	.90	....	5.04	39.72	30.48	2.48	....
10244.....	28.41	....	26.14	....	4.92	13.63	....	26.90	....
10245.....	28.09	....	25.84	....	7.11	7.49	....	31.47	....
10248.....	11.91	....	5.95	....	12.52	18.68	33.69	17.25	....
10249.....	14.40	....	2.36	8.03	14.27	56.83	....	4.11	....
10250.....	29.56	....	8.17	11.95	4.40	4.40	....	41.52	....
10251.....	27.74	....	19.35	2.36	14.42	21.94	....	14.19	....
10253.....	10.88	....	4.85	1.74	12.35	62.50	....	7.68	....
10254.....	12.24	1.86	....	8.71	12.86	60.91	....	3.42	....
10255.....	10.35	....	2.30	....	22.05	53.99	3.26	8.05	....

Chemical analyses of samples of alkali soils, Yuma area, Arizona—Continued.

CONSTITUENTS—CONVENTIONAL COMBINATIONS—Continued.

Laboratory No.	Calcium sulphate ($CaSO_4$).	Calcium chloride ($CaCl_2$).	Magnesium sulphate $MgSO_4$).	Magnesium chloride ($MgCl_2$).	Potassium chloride (KCl).	Sodium chloride (NaCl).	Sodium sulphate (Na_2SO_4)	Sodium bicarbonate ($NaHCO_3$)	Sodium carbonate (Na_2CO_3)
10256			7.09		17.16	47.03	12.13	9.14	7.45
10257	14.91		4.86	1.25	6.59	58.73		13.66	
10260	9.29		2.43	2.73	7.21	75.91		2.43	
10261	7.03		2.54		8.17	54.20	23.64	4.42	
10262	21.54	3.38		4.86	8.16	56.62		5.44	
10263			5.33		13.56	61.55	8.11	11.45	
10264	9.24	36.83		11.91	3.64	34.58		3.80	
10265	6.79		5.34		9.86	61.46	9.86	6.69	
10267	14.47	30.68		11.86	18.06	17.21		7.72	
10268	5.16		3.84		6.78	34.12	41.60	8.50	
10269	2.80		3.80		19.84	44.90	11.82	16.84	
10270	7.02		2.80		14.63	29.78	39.05	6.72	
10273	20.33	12.17		12.17	13.87	30.57		10.89	
10274	18.86	5.54		7.95	11.27	44.18		12.20	
10275	21.34	1.01		7.03	5.61	63.86		1.15	
10277	2.87		1.98		6.77	69.30	13.34	5.74	
10279	22.57		12.16		12.88	31.82	8.76	11.81	
10285	23.17		7.29		13.09	34.14	1.07	21.24	
10289			27.55		8.67	2.04	2.55	59.19	
10290	12.95		5.50	8.53	8.26	27.84		36.92	

The alkali of the valley lands is purely a surface accumulation—that is, nearly all the salt is included at least in the surface 6 feet, and in many cases is found only in the first 3 feet. Since its accumulation is due to evaporation from the surface, its presence as a surface accumulation is not strange. In the case of the lands subject to annual overflow, where there is a slight accumulation of alkali after subsidence of the floods, the alkali is wholly a surface accumulation, practically all of it being found in the first inch or so of soil. The areas immediately surrounding present overflow land, which annually have the water table raised near the surface, but have not been flooded for many years, have the alkali distributed through from 1 to 4 feet of the soil, depending upon its texture and the height to which the water table is raised. In the lighter, sandier soils the alkali is nearly all in the surface foot, while in the heavier, slowly penetrable soils the alkali often extends to a depth of 4 or 5 feet.

Along the mesa lands, or below the bluff line, the alkali conditions are not so recent in origin, but have been maintained for a long time, or since the mesa was drained after its elevation above water. The water table here is not at present near the surface, and is not raised annually, so that the alkali has been partly washed into the subsoil, which is quite heavy and readily retains the salts. Here the alkali is usually distributed more evenly throughout the surface 6 feet, and in some instances extends below the sixth foot in noticeable quantities.

Accompanying this report is an alkali map, showing in colors areas containing less than 0.20 per cent, from 0.20 to 0.40 per cent, from 0.40 to 0.60 per cent, from 0.60 to 1 per cent, from 1 to 3 per cent, and more than 3 per cent. This map was constructed from a great many borings and tests made in the field, about one boring to each 40 acres being made in the alkali-affected districts. The map shows the average per cent for the surface 6 feet, while on the classification sheets the percentage for the surface foot is also shown. A comparison of the percentages for the surface foot and the average for the 6 feet will illustrate the greater amount found in the surface.

The following table shows the number of acres and the percentage of the area mapped, covered by each of the grades of alkali soil above mentioned:

Area of different grades of alkali soil.

Grade of soil.	Acres.	Per cent of area.
Less than 0.20 per cent	177,408	81.5
From 0.20 to 0.40 per cent	15,168	6.9
From 0.40 to 0.60 per cent	6,208	2.8
From 0.60 to 1 per cent	5,376	2.5
From 1 to 3 per cent	8,896	4.2
Over 3 per cent	4,352	2.1
Total	217,408	

AGRICULTURAL CONDITIONS.

No farming worthy of the name is being attempted in that part of the valley and delta included in this survey. Immediately below Yuma, however, as already pointed out, in what is known as Yuma Valley, alfalfa, grain, vegetables, corn, sorghum, and in fact all the common field crops, besides deciduous fruits and grapes, have been produced in considerable quantities for a number of years. Corn and other summer crops have also been grown, after the subsidence of the overflow, without irrigation. A few who have tried this farming after the overflow have been quite successful, and no doubt much could be done in this way pending the completion of the irrigation works and dikes. On the mesa land, near Yuma, there is a grove of oranges, a few vines, and some deciduous fruits which do fairly well. This is the Blaisdell tract, mentioned before in the course of this report. Under a high state of cultivation, with plenty of water, such fruits would no doubt prove valuable.

Labor is scarce and quite high. Nearly all the work of the farms is now done by either Mexicans or Indians, who receive from $1 to $1.50 a day, with board in addition.

SOIL SURVEY OF THE SACRAMENTO AR

By MACY H. LAPHAM, ALDERT S. ROOT, a

LOCATION AND BOUNDARIES OF TH

The Sacramento area lies partly within and southeastern portion of the Sacramento Valley. by the Sacramento River, a stream navigable above its mouth, is a very important physio forms the northern half of the great interior valley of California.

The area mapped embraces the territory covered by the topographic and geologic work of the United States Geological Survey and published as the Sacramento sheet, the limits of which are meridians 121° and 121° 30′ west longitude, and parallels 38° 30′ and 39° north latitude. It contains about 924 square miles, and embraces important fruit-producing lands of the Sierra Nevada foothills, as well as large tracts extending outward to the valley trough devoted to dairying, stock raising, and the prod wine and table grapes, fruits, vegetables, and of the orchard and farm.

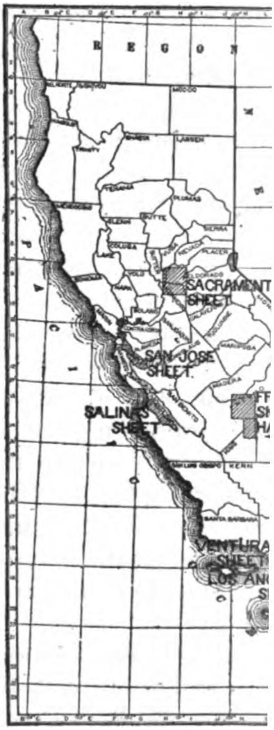

FIG. 43.—Sketch map showin
area, Ca

During the Mexican régime, between the years 1822 and 1846, a few white settlers, explorers, and adventurers found their way into this section. In certain cases they received large grants of land from the Mexican Government. Among those so favored was Gen. John A. Sutter, who in 1839 built Sutter's Fort on the present site of the city of Sacramento. In 1844 he founded the first settlement, at Sutterville, 3 miles below the fort, on the Sacramento River. Here he planted small plats of wheat, tobacco, and a few fruit trees and vines.

With the discovery of gold in 1848, and the subsequent coming of the gold seekers, stores and trading posts were established. Sutterville was abandoned, and Sacramento, at the site of the historic fort, became the halting place of the steamboat and wagon train and the main outfitting point for the mines. Small surrounding mining towns and settlements, notably those of Auburn, Ophir, Folsom City, and Lincoln, sprang into prominence, farms multiplied, population increased, and the organization of civil districts took place rapidly.

In early days a few flocks and herds of sheep and cattle were brought across the Plains, and, as they rapidly increased, the foundation of a great live-stock industry was laid. Large tracts of Government land were purchased at slight cost, and many of the large Mexican grants were acquired for grazing purposes. Later the growing populations of the mines and towns and the invention of labor-saving farm machinery turned the attention of the holders of these large tracts to the production of grain.

For many years exploitation rather than development was the ruling passion. Mining was carried on with a restless zeal, and there was little indication of a future agricultural development. Whole fields and hillsides were cut with unsightly gashes and pits or removed bodily and sluiced into the ravines and canyons to be washed by the flood waters into the valleys below. Farms were covered with débris, and the stream channels were filled with sand and gravel. Unrestricted hydraulic mining was finally prohibited by law, but with every passing flood the harvest of débris—"slickens," as it is called—still goes on.

Stage and express lines were early established between the towns and the principal mines, and a railroad, the first in the State, was built connecting Sacramento, Folsom City, and Lincoln. This was followed in 1869 by the completion of the first overland railroad, the Central Pacific, to Sacramento, which remained the terminus for some time.

Many of those who came for gold, being disappointed, turned their attention to farming. This population was drawn largely from eastern States, but was augmented by many foreigners from all parts of the civilized world. Recent immigration has emphasized the cosmopolitan phase of the population.

The growing of grapes, hops, tree fruits, and small fruits began in a small way as early as the sixties. The possibility of successful orange culture, however, was not fully demonstrated until many years later, and it was not until the period from 1888 to 1890 that the production of all kinds of fruit received its greatest stimulus and eastern shipments in large quantities began. The clearing of the brush-covered slopes and planting to orchards and vineyards, and the transition from the extensive grain ranches to small intensively cultivated tracts, is still in progress.

CLIMATE.

The climate of the Sacramento area, like that of the whole northern and central interior of California, is semiarid. Two seasons—the wet and the dry—occur. Light or moderate rainfall, mild winters, warm or hot summers, low relative humidity, and light wind movement are the prevailing climatic conditions, which correspond closely with those of the citrus belt of northern Italy.

The average annual precipitation over the area surveyed varies from about 20 inches in the valley to 40 or more inches in the higher foothills. The rainy season usually begins about the middle of October and continues until the middle of May, although the dates fluctuate widely. The greater proportion of the annual rainfall, however, takes place from November to March, inclusive. The rains are sometimes heavy, but usually fall in steady or gentle showers. They are very rarely accompanied by violent winds, thunder, or lightning, and cloudbursts are almost unknown. Destructive floods during periods of heavy precipitation sometimes occur, but these are the result of topographic conditions rather than excessive rainfall. During the months of April and May showers only occasionally occur. During the summer there is no precipitation of importance, frequently none at all. Snow or hail at any season of the year is of very rare occurrence.

The average annual temperature varies but slightly throughout the area, although it becomes slightly lower in the higher foothills. At Sacramento it is about 60° F., at Rocklin about 62° F., and at Auburn a fraction above that at Sacramento. During the winter frosts occur frequently in the valley and higher foothills, but are less severe and less frequent in the "thermal belt," extending along the foothills with an elevation of from 200 to 1,400 feet, within which zone the cultivation of citrus fruits is possible. While the average annual temperature here is about the same as that of the citrus-producing sections of southern California, the summer temperature is somewhat higher, forcing the fruit to an earlier maturity. The oranges are sometimes slightly frosted, but the trees are seldom damaged. Late spring frosts rarely occur, and damage to early fruit from this cause is infrequent. During the summer the days are frequently hot, with a temperature sometimes of from 90° F. to 100° F., or more; the nights, however, are usually cool and pleasant. The average annual range in temperature at Sacramento is about 88° F.

The following table shows the normal monthly and annual temperature and precipitation at Sacramento, Rocklin, and Auburn:

Normal monthly and annual temperature and precipitation.

Month.	Sacramento.		Rocklin.		Auburn.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	° F.	*Inches.*	*° F.*	*Inches.*	*° F.*	*Inches.*
January	46.4	3.82	46.4	4.16	45.6	5.88
February	50.5	2.65	49.8	3.14	48.1	4.85
March	54.8	2.94	54.9	2.90	51.7	5.14
April	59.3	2.28	60.4	2.98	56.5	3.21
May	64.2	.96	67.8	1.08	62.7	1.56
June	70.2	.17	79.0	.23	70.8	.43
July	73.6	.00	80.0	.08	76.8	.02
August	72.6	.00	78.2	.04	75.9	.02
September	69.5	.36	72.7	.18	71.0	.48
October	62.8	.90	63.6	1.14	64.6	1.87
November	53.5	2.15	53.9	2.29	55.0	3.93
December	47.0	4.14	47.9	3.77	47.0	6.07
Year	60.3	20.37	62.8	21.89	60.5	33.46

While the summer temperature is high, the relative humidity is usually low, increasing somewhat in the vicinity of the larger streams and other bodies of water. This greatly reduces the sensible temperature, rendering the heat of summer less oppressive and enervating. Humid periods are usually of short duration and infrequent occurrence.

Upon the north, east, and west sides the area is sheltered by high mountains, protecting the valley and foothills from the cold winter winds and storms of the north and east, and from the chilling sea breezes from the Pacific. During the summer the modified sea breeze from the Golden Gate usually passes up the Sacramento River and reaches the valley late in the afternoon. The wind movement is usually quite steady and prevailingly from south to southwest. During the summer hot, dry winds from the north, generally continuing from one to three or four days, are occasionally experienced. These are in striking contrast to the cooling sea breezes, and sometimes scorch the unprotected and unshaded tender vines and ripening fruit.

along the rivers during the night, but are soon (
ing's sun. The total number of clear days at Sa
high. During the winter, however, rain clouds
frequent occurrence, the valley and the lower
more or less enshrouded in fog for periods of se

In general the climate is healthful and such
tural and agricultural industries. During the
portion of the rainfall makes its way into the
the future needs of the plants, and there is
evaporation. The temperature favors the grow
of crops and fruits with little danger of injury
the summer farming operations are rarely inter
weather and the processes of fruit drying, ha
go on without danger of damage to the crop fro
conditions.

PHYSIOGRAPHY AND GEOLOGY

The elevation varies from 30 feet above sea l
about 2,100 feet at the opposite or northeaster
and the slopes vary from the almost dead level
the precipitous and mountainous hillsides of t
hills. Drainage of the uplands is effected b
streams and minor ravine channels. The most
tent in character, carrying water only during
cross the valley plain as insignificant meande
their flood waters into the main drainage strean
latter, the American River, with its three fork
among the hills of the eastern and northeastern
is the most important. This river during the
great quantity of water, and from the juncti
South forks near Folsom City traverses the so
area in a southwesterly direction and empties
River just after leaving the area. The Bear
also streams of considerable importance and su
cross the northwestern and southeastern corne
tively. The main creeks, crossing the valle
southwesterly direction, flow into the Sacramen
the western boundary of the area. During th
the larger streams of the area, rising in the hi
hills, carry any flow of importance.

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[a] For much of the data concerning the topographic
the area we are indebted to the United States Geolo
logic Atlas of the United States, Sacramento sheet.)
marked by great variety and complexity.

area surveyed, the towns of Lincoln, Roseville, Rocklin, and Folsom City nearly marking its boundary. The surface of the extreme western or lower portion is nearly level, but often covered by small mounds known as "hog wallows," which form a distinctive feature over much of the Sacramento and San Joaquin valley lands. These are most prominent along the western and that portion of the southwestern margin of the area lying on the north side of the American River. In the extreme southwestern portion small knoblike elevations give moderate physiographic relief to the landscape. The Bear and American rivers flow through wide, shallow channels but little below the surrounding country, which, when unprotected by artificial levees, is subject to inundation during high water. Valley oaks in considerable numbers frequently occur upon the undulations of the valley plain and in the vicinity of the river bottoms, while the stream courses are frequently fringed with oaks, cottonwoods, and willows. In the American and Bear river bottoms this growth of trees and brush is exceedingly dense. Aside from these features the plains are generally treeless.

Along the higher slopes of the valley plain the level character of the surface gives way to an undulating plain or a succession of rolling hills. The streams are here somewhat below the surrounding level and are often marked by lines of bluffs, as at Fairoaks, while the growth of oaks upon the undulations and ridges is increased.

In the belt of the lower foothills a distinctive physiographic feature consists of a series of barren, flat-topped volcanic ridges and knobs extending in a southwesterly direction from Auburn to the valley below. In the same vicinity, in contrast to these and followed by the main line of the Southern Pacific Railway, lies a trough or depression eroded from the coarse granitic rock. With the exception of the flat-topped ridges the lower hills are usually of rounded or domelike contour, with gentle slope. The streams have cut their way through rocky ravines and gorges, and in this natural condition the slopes are frequently covered with quite a heavy growth of the valley oak and liveoak, California buckeye, "digger" or grayleaf pine, coffeeberry, manzanita, species of ceanothus, and other characteristic trees and shrubs of the lower Sierra Nevada foothills.

With further increase in elevation, the slopes become steeper, the ridges sharper and more rugged, while the streams flow through deep and narrow canyons. That of the North Fork of the American River near Auburn is about 1,000 feet deep, with precipitous forested slopes. In addition to vegetation previously mentioned, a rather dense growth of yellow pine is seen, which in the high and more rugged hills east of the American River gives way to a dense, thorny the latter being locally known as "greasewood."

The rocks of this area consist of those laid do subsequently more or less consolidated, those ej or intruded into adjacent rock masses from v fissures, or rocks of both these classes or of uncer fied by heat or pressure as to assume entirely ne

The geology of the foothills is important in it formed by long-continued disintegration and d rocks. The influence of the properties of the where seen in the resulting soils. The older ro rule, been subjected to great heat and pressure tured, tilted, and crushed in a complex manner.

The prevailing rocks of the higher foothills and diabases, the former being of schistose, o structure, and the latter frequently of dense, co fine granular texture. The prevailing color is with minor bodies of sedimentary and intrusiv rocks, occupy the eastern portion of the area. T iron and weather into moderately heavy, red lo texture, frequently carrying a small percentage shaly fragments or gravel. The hills composed ally have quite steep slopes and occur in ridge with the main Sierra Nevada Range. The soil p is usually of a deeper red color and somewhat he that derived from the amphibolite.

In the vicinity of Clipper Gap there is a c rock, consisting of limestones, slates, and dark the resulting soil, which is nearly identical wi the weathering schists and diabases, the propert limestones predominate. As with the diabase an quantities of flat, shaly gravel frequently occur outcrop is frequent and sometimes excessive. M bodies of this formation occur throughout the the area.

Extending southeastward across the area fr mile southeast of Folsom City there are bodies o The main body averages about 1 mile in width, three small and narrow parallel bodies to the e outcrops in sharp, jagged projections and ledge slowly into a light-gray or drab loam. The surf of trees or shrubs, and the soil is shallow and u

In the high hills and brush-covered slopes in Hill, and to the southeast of Salmon Falls, occ granular rock, dark green or gray in color, classed as gabbrodiorite. This rock is extremely dense and resistant to the weather. It decomposes into a very heavy, compact clay loam of deep-red color, often resembling adobe and containing fine angular fragments. It frequently outcrops to such a degree as to render the land of no agricultural value, although when deep enough to support crops the soil is productive and valuable. Two or three small bodies of a modified form of this rock occur about 5 miles east of Sheridan, weathering into a productive, mellow, black sandy loam.

A few small, irregular bodies of serpentine rock are found near the eastern margin of the area surveyed. These are most prominent in the high, rugged hills in the vicinity of Flagstaff Hill and adjacent to the gabbrodiorite area near Salmon Falls. This formation is usually very dense, but is sometimes altered to white, slaty rock. It weathers very slowly, and the soil, which is very shallow or almost entirely wanting, is generally unproductive.

The greater portion of the lower foothills, lying between the towns of Auburn, Lincoln, Rocklin, and Folsom City, consists of a coarse granular, granitic rock—granodiorite—which is more easily eroded than those of the higher foothills. It disintegrates rapidly, but decomposes slowly, forming a red, gray, or dark colored coarse, granular sandy loam or loam containing usually an abundance of fine angular rock particles. The rock outcrops frequently as huge bowlders or masses, but the soil is very productive and largely devoted to the growing of deciduous fruits. A rough, rocky body of this formation devoted to grazing purposes occurs in the northeastern portion of the area.

Auriferous or gold-bearing gravels have accumulated along ancient and modern stream channels, and in recent times they have been greatly disturbed by processes of mining.

The flat-topped table-lands, to which reference has previously been made, in many cases cover the gold-bearing gravels and ancient stream channels, into which the volcanic muds and lavas were poured. Subsequent erosion of adjacent softer rock masses has left these bodies standing high above the surrounding country. The material consists of volcanic tufaceous breccia, in which are embedded fragments and bowlders of andesite rock.

Along the base of the foothills a series of white sands and clays are frequently exposed, especially in the vicinity of Lincoln and Rocklin and along the southern margin of the area to the southward from Folsom City. This deposit of sedimentary material was laid down under the waters of a shallow bay or inland sea at one time occupying the Sacramento Valley. This formation gives rise to sands, sandy loams, and more frequently to heavy dark-colored adobe.

The valley plain consists of alluvial material washed from the hills or carried into the ancient lake or sea bed in Pleistocene times. The presence of hardpan is general throughout this material, and strata of well-rounded gravel also frequently occur.

The river bottoms are usually marked by deep deposits of fine alluvial sands, silts, and clays.

SOILS.

The soils of the Sacramento area, like the physiographic, geologic, and general agricultural conditions, exhibit great variety and complexity. As a rule, they are productive and possess marked moisture-retaining properties. They are frequently highly colored and grade from one to another by imperceptible degrees. Sixteen types of soil were recognized, which, owing to natural physiographic and geological distinctions, fall with slight exception into two natural and well-defined groups, viz, the soils of the valley plain and the soils of the foothill belt.

In certain sections, particularly in the vicinity of Folsom City, the soils have been greatly disturbed by mining operations, producing unsightly beds and heaps of gravel, as well as deep and dangerous pits and trenches, in many cases rendering the land unfit for any agricultural use whatever. While the greater part of the lands so affected was originally suited only to grazing purposes, the extensive dredging operations are slowly encroaching upon the more valuable fruit and vineyard lands.

These barren and nearly worthless lands, as well as those marked by excessive rock outcrop or otherwise stony condition, are indicated upon the map by the proper symbols.

The soils of the valley plain occupy the western half of the area, which consists of nearly level plains and undulating slopes, stream bottoms, and flood plains. According to physiography, origin, and other natural features they are again divided into three groups, viz, those of the San Joaquin series, those of the Sacramento series, and miscellaneous soils. The soils of the San Joaquin series consist of the original alluvial material washed into the waters of the bay occupying the valley in Pleistocene times, and are generally underlain by red sandstone hardpan of secondary formation. The soils of the Sacramento series consist more of recent sediments derived from stream wash, while the miscellaneous soils are those not included in the two series mentioned.

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
San Joaquin sandy loam	265,216	44.8	Fresno fine sand	6,656	1.1
Sierra clay loam	128,183	21.6	Fresno gravel	4,544	.8
Sierra sandy loam	64,448	10.9	San Joaquin red adobe	3,776	.6
San Joaquin fine sandy loam	30,208	5.2	Fresno red sand	1,920	.4
Sierra stony loam	30,080	5.2	Sheridan sandy loam	1,792	.3
Rough stony land	19,839	3.3	Fresno sand	1,408	.2
Salinas gray adobe	12,672	2.2	Riverwash	778	.1
Sierra loam	10,944	1.8	Total	591,488	....
Sacramento silt loam	9,024	1.5			

SAN JOAQUIN SANDY LOAM.

The San Joaquin sandy loam consists of a loam or light-red sandy loam of medium to fine texture, but often carrying small quantities of coarser sharp fragments, the main body of the soil being fine, smooth, and somewhat silty in character. The average depth is about 3 feet, although subject to great variation. This material is underlain by a dense refractory red hardpan of very much the same texture as the overlying soil. The soil is sometimes separated from the hardpan by a stratum, usually but a few inches in thickness, of red sandy adobe of sticky character and dense structure, checking into small roughly cubical blocks. The underlying hardpan in most cases consists of several layers from a few inches to several feet in thickness, interstratified with red or light-colored sands, fine sediment, or gray or red sandy adobe.

In certan parts of the area, especially in the vicinity and north of Dry Creek, and also in the vicinity of the lower granitic foothills, coarse angular particles of rock, derived from disintegration of the granites, occur in both the soil and underlying hardpan. Heavy phases of the soil occur which grade into the adjacent loams.

In area the San Joaquin sandy loam is the most important soil type in the district surveyed. Except in the vicinity of the flood plains of the larger streams it covers nearly the entire western half of the area. The type is subject to considerable minor variation, but, aside from this characteristic, it occurs in great tracts of nearly uniform soil.

It extends from the lower level valley floor of the western margin of the area upward to the base of the foothills. The lower levels are frequently marked by the hog-wallow mounds, while the valley slopes in the vicinity of Fairoaks and Orangevale are quite rolling and hilly. The underlying arenaceous hardpan frequently outcrops along the margins of the ridges or is exposed at the surface near streams by erosion from flood waters. Gravel frequently occurs, especially in the vicinity of minor foothill streams and along the southern margin of the area. The lower levels of shallow soil are generally treeless, but along stream courses, where the hardpan is

frequently broken, and upon the upper valley s
and groves appear.

The San Joaquin sandy loam, although contai
proportion of sand, is of compact structure, and
adobe. It very readily puddles if worked while
and bakes hard upon exposure. Upon the level
valley plains, where surface drainage is insuffic
rains, the soil often becomes very soft and bog
underlying hardpan allowing little or no percolati
Upon the steeper slopes and undulating topogr
valley slopes drainage takes place more readily.

This soil is derived from the adjacent granitic,
morphic rocks, the granitic material being the
material, from whatever sources, was washed fron
deposited in the waters of the Pleistocene lake or
ing hardpan is believed to be a secondary form
in more recent times, and caused by the precipit
insoluble iron salts mixed with particles of clay.
gone considerable modification in places by recent

The most important natural feature of this soil
view of the agriculturist is the underlying impervi
does not soften upon application of water, and we
grates very slowly. Alkali salts do not occur in t
quantities.

The crops to which the San Joaquin sandy loa
widely, according to depth at which the hardpan
the areas as regards topography, elevation, and l
tions. Throughout the zone of shallow soil o
lower valley plain it is adapted only to grazing, g
shallow-rooted crops, except along stream courses
ous hardpan strata are sometimes broken. W
hardpan is 3 feet or more it is, in general, adapt
berries, and citrus and deciduous fruits.

The lower valley plains are devoted generall
extensive dry farming to wheat, oats, barley, a
fair yields in favorable seasons. The upper v
undulating slopes are cultivated to grains and h
gated to vines, berries, peaches, cherries, plums,
ous fruits, with profitable yields during favora
and oranges are also grown to some extent in the
and Orangevale, and in areas of deep soil, and wi
they do well.

The long-continued growing of wheat in c
caused a decrease in the productivity of this
now being sometimes devoted to oats, barley, ry

A heavy phase of this soil of brighter red color and more loamy texture occurs along the upper valley slopes adjacent to the heavy red loams of the foothills. It is most prominent eastward from Sheridan, and southward from Folsom City. In topographic and drainage features, general origin, and character of underlying material it is identical with the typical soil. It departs from it only in the texture and properties of the soil, being finer, heavier, more sticky when wet, and somewhat more retentive of moisture. It has been considerably modified by recent wash from the adjacent hills. The areas of this phase are devoted mainly to grains and grazing, although grapes do well when properly irrigated and cultivated.

Another phase occurs in limited bodies on the lower valley, grading into adjoining bodies of heavy sediments and adobes. In general features and agricultural value it does not differ greatly from the adjoining soils, but it is of a darker color and a more compact structure than the typical San Joaquin sandy loam.

The following table gives the result of mechanical analyses of both soil and subsoil of the San Joaquin sandy loam:

Mechanical analyses of San Joaquin sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12012	1 mile NE. of Fairoaks.	Medium sandy loam, 0 to 12 inches.	1.6	13.4	13.7	27.1	11.9	21.0	10.9
12009	6 miles NE. of Sacramento.	Medium sandy loam, 0 to 12 inches.	1.3	6.4	4.9	19.1	12.7	40.1	15.2
12001	2¼ miles SE. of Walsh Station.	Red sandy loam, 0 to 12 inches.	2.3	7.5	4.5	14.9	15.3	37.4	18.0
12013	Subsoil of 12012	Red sandy loam, 12 to 48 inches.	.8	10.8	9.3	25.8	14.6	22.9	15.5
12010	Subsoil of 12009	Red clay loam, 12 to 18 inches.	.2	3.1	3.2	15.7	16.3	34.9	25.8

SAN JOAQUIN FINE SANDY LOAM.

The San Joaquin fine sandy loam consists of a buff to red fine sandy loam of smooth texture and with but little sharp material, rather sticky when wet and somewhat resembling silt loam, and when dry frequently exhibiting a moderately compact and close structure. In depth, it is subject to some variation, but is generally underlain at about 3 feet by a stratum of heavy light-brown or red loam or clay loam grading into red hardpan, of fine sandy or clayey texture. The underlying material is similar to that of the San Joaquin sandy loam, except that the fine heavy loam generally takes the place of the sandy adobe, the hardpan being in itself generally of a somewhat finer texture and frequently less dense and continuous.

This soil type occurs mainly in the southwestern part of the area in one extensive and uniform body, lying southward from the American River. It occupies the upper bench of the ancient flood plain of that river, and extends in a southwesterly direction across the lower valley plain. The surface, aside from minor irregularities, is smooth, nearly level or gently sloping, and devoid of prominent topographic features. The type is in places separated from adjacent soils by slight terrace lines, and generally lies below the San Joaquin sandy loam. Near the river and more recent sedimentary soils, irregular gravelly bodies sometimes occur.

During wet periods the drainage conditions in this soil are like those of the San Joaquin sandy loam. It has, however, been subjected to modification by fine alluvial sediments from the flood waters of the American and possibly from the Sacramento River. Like the San Joaquin sandy loam, it possesses marked moisture-retaining properties, and is free from alkali salts. The soil when not too shallow is well adapted to stone fruits, grapes, and berries, as well as to dry farming to grain or hay. Wheat and other grains are extensively grown upon unirrigated tracts, the yields being generally good. Irrigated lands are intensively cultivated to grapes, the early and desirable Flame Tokay being in great demand, as well as to strawberries, bramble berries, and vegetables. Strawberry and table grape culture are popular and profitable industries upon this soil, which is generally more productive than the San Joaquin sandy loam.

The following table gives the result of mechanical analyses of this type of soil:

Mechanical analyses of San Joaquin fine sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
12017	Walsh Station	Fine sandy loam, 0 to 12 inches.	0.5	4.5	5.3	39.2	21.3	18.8	9.9
12020	1½ miles S. of Perkins.	Loam, 0 to 12 inches	1.8	5.0	2.9	12.6	15.6	38.2	23.7
12018	Subsoil of 12017	Fine sandy loam, 12 to 54 inches.	1.2	9.7	9.4	35.2	16.8	17.7	9.5
12021	Subsoil of 12020	Clay loam, 12 to 36 inches.	.7	2.7	1.7	10.9	16.4	40.2	27.2

SAN JOAQUIN RED ADOBE.

The San Joaquin red adobe is a heavy red adobe, possessing the texture of a heavy loam or clay loam, usually about 3 feet deep, though varying greatly in depth, and underlain by the red sandy hardpan described in the preceding types of soil. The soil when wet is exceedingly tenacious and sticky, puddles readily, and bakes upon exposure to the sun. Small checks, extending to a depth of several inches, frequently appear, dividing the soil into cubical blocks. Small white angular rock fragments and fine, sharp gravel frequently occur in both soil and underlying hardpan.

The San Joaquin red adobe is not an important type, occurring only in a single area of a few square miles extent, and in one other smaller tract. These are found about 5 miles north of Pleasant Grove. The type occupies only the lower, nearly level slopes of the valley plain, and is unmarked by distinct topographic features. The surface is generally smooth, save for occasional mounds and minor irregularities. Except in the vicinity of the drainage channels, the surface is usually barren of trees or shrubs.

Owing to the dense structure of this soil, and to the impervious underlying hardpan, percolation and drainage take place slowly, while during the dry season it becomes very dry and compact.

Like the preceding soils of the San Joaquin series the San Joaquin red adobe is derived primarily from alluvial wash from the adjacent hills, composed of granites, diabase, amphibolite, and other rocks of volcanic and metamorphic origin. The present soil is, however, probably formed in part through the disintegration of underlying hardpan.

On account of its heavy texture and peculiar structure the soil is capable of receiving and storing large quantities of moisture. If the surface is prevented from baking, and the supply of underground moisture preserved by proper cultivation, a large proportion of the rainfall is rendered available for growing crops. The peculiar structural condition of this soil, while requiring careful treatment in order to prevent puddling and baking, becomes of great importance in the growing of shallow-rooted unirrigated crops.

The San Joaquin red adobe is devoted almost exclusively to dry farming grain and hay, with excellent yields in favorable seasons and with proper cultivation. Care should be taken to prevent the compacting or puddling of the surface, either by the tramping of stock or by farming operations. Thorough harrowing is of importance in counteracting the natural tendency of the soil toward this condition.

of soil are shown in the following table:

Mechanical analyses of San Joaquin r

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.
			P. ct.	*P. ct*
12024	3¼ miles N. of Pleasant Grove.	Clay loam, 0 to 12 inches.	1.4	3.1
12025	Subsoil of 12024	Heavy clay loam, 12 to 60 inches.	1.1	5.1

FRESNO GRAVEL.

The Fresno gravel consists of all grades of
occasional small bowlders, usually well rounde
and fine river sands, and in places with heavie
erally extends to a depth of 6 feet and is und
and hardpan. In the foothill belt, however, i
depth, and is underlain by the prevailing rock o
it occurs.

The larger bodies of the type occur along the
in the vicinity of Fairoaks and Folsom City.
occur throughout the foothills belt along ancie
channels, and in many instances these were t
upon the map.

The larger bodies of this soil in the vicinity of
City, occurring along the lower benches of the
frequently separated from adjacent recent riv
terraces, while the bodies upon the north side
rated from the adjacent and higher lying Sa
by prominent bluffs. The finer material of
covers the coarser gravel and often supports a
willow, small cottonwood, and other trees an
bottoms. The smaller areas of the foothills oc
or occupy ravines. Over much of the larger
gravel has been greatly disturbed in recent t
other mining operations, which usually leave t
of great heaps of cobbles separated by deep pi

In its original condition the Fresno gravel
a result of mining operations much of the w

pits, underlain by impervious hardpan or rock, during the rainy season.

All of the rocks of the Sierra Nevada Mountains and foothills are represented in these deposits, which have been spread about by rapidly moving and shifting currents of the streams during flood seasons. Some of the smaller outlying bodies are largely of colluvial or residual origin, the materials having been transported but short distances.

This type in its natural condition is adapted only to grazing, but where it has been subjected to dredging or other mining operations it is unfit for any agricultural use whatever.

FRESNO SAND.

The Fresno sand consists of a loose, incoherent sand of light color, generally 6 feet or more in depth, and underlain by fine loam, river gravel, and red arenaceous hardpan. It grades into the adjacent river gravel and recent river sediments.

This soil type is of little importance in the Sacramento area. It occurs only in a few irregular bodies adjacent to the American River, near Fairoaks, and also to a greater extent in the vicinity of Bear River. It occupies lower or intermediate terraces along the streams and has a level surface, sometimes gravelly, but devoid of rock outcrop or prominent physiographic features. Owing to its open texture and loose, porous structure, this soil is well drained, except in the vicinity of the Bear River, where it is sometimes subject to overflow.

The materials of the Fresno sand are derived from the varied rocks of the Sierra Nevada Mountains and foothills, particles of quartz, mica, and feldspar being the most prominent. This material has been deposited in its present position by the shifting currents and flood waters of the adjacent streams.

Owing to its texture and structure the Fresno sand is naturally free from alkali salts, while the underlying hardpan lies at such depth as to have little effect upon the growth of crops.

Types of soil of this class are less retentive of moisture than those possessing a heavier subsoil, but are well adapted to grapes and stone fruits requiring well-drained soils, which can be irrigated during the dry season. As there is practically no danger from puddling, cultivation can be practiced at almost any time, thus preventing the loss of much soil moisture after irrigation or rains.

In the vicinity of Fairoaks the Fresno sand is devoted largely to grapes and stone fruits, with excellent yields under effective systems of irrigation and cultivation.

The results of mechanical analyses of this soil type are shown in the following table:

Mechanical analyses of Fresno sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12026	Fairoaks Bridge.....	Coarse sand, 0 to 12 inches.	1.4	15.4	16.8	32.8	14.2	12.4	7.2
11990	1 mile S. of Fairoaks.	Coarse sand, 0 to 12 inches.	4.0	17.9	15.6	31.7	10.9	11.4	8.3
12027	Subsoil of 12026	Coarse sand, 12 to 72 inches	1.2	12.8	15.8	37.7	13.5	13.8	5.2
11991	Subsoil of 11990	Brown coarse sand, 12 to 72 inches.	1.9	18.0	14.6	31.3	11.5	13.3	9.1

FRESNO FINE SAND.

The Fresno fine sand consists of about 3 feet of micaceous fine sand, from a light-yellow to brown or drab color, underlain by micaceous fine sandy loam, streaked with coarse or fine sands. The depth of soil and character of subsoil are, however, subject to considerable variation.

The main bodies of the type occur as rather narrow areas upon each side of the American River, extending from Mills Station to the western margin of the area. Smaller and less important bodies occur south of Sacramento, near Fairoaks, and also in the vicinity of Bear River. These several areas occupy the lower terraces and bottom lands of the lower courses of the larger streams of the area. The soil has a level surface, is sometimes gravelly, and frequently separated from adjacent soil types by minor terrace lines, and in its original condition is usually covered by a dense growth of willows and brush.

Natural drainage is favored by the open porous texture of the soil and subsoil. Owing to the position of the lower lying bodies, however, the soil in the vicinity of Sacramento and along Bear River is somewhat subject to overflow and seepage waters during the winter and spring floods. Protection by levees is necessary, and artificial drainage is sometimes required during wet periods.

The Fresno fine sand originates with the fine micaceous material derived from the granitic, diabasic, and fine-textured rocks of the foothills and mountains, deposited over the flood plains from the slack flood waters of the main streams.

The micaceous material is a very prominent constituent, imparting a smooth, greasy feel to the soil. Owing to the rapidity of capillary the lower lying bodies, alkali salts have here accumulated in the surface of the soil to a slight extent, it is believed, through the concentration of minute quantities occurring in the sediments. The alkali is not found in sufficient quantities to interfere with plant growth, and owing to soil structure, frequent natural flooding, and the penetration of the loose, porous soils by moderately heavy rainfalls damage from this source is not likely to occur.

The depth of the soil in this type and the usual moist condition of the subsoil allows alfalfa to be grown upon the lower bodies with little or no irrigation, provided the crop be protected from overflow and seepage from streams during long-continued flood periods. The soil is easily cultivated and excellently adapted to berries, vegetables, pears, stone fruits, hops, and asparagus. In point of variety and yield of intensively cultivated crops, this soil is among the most important of the area. Hops, asparagus, vines, fruits, and vegetables are the important crops grown. Alfalfa is also grown to a slight extent in connection with the dairying industry.

The following table shows the results of mechanical analyses of this type of soil:

Mechanical analyses of Fresno fine sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12028	¼ mile N. of Man Love.	Yellow fine sand, 0 to 36 inches.	0.1	1.1	1.8	26.3	32.0	32.6	6.5
11992	1 mile NE. of Sacramento.	Heavy fine sand, 0 to 12 inches.	Tr.	1.3	4.1	28.7	28.5	28.2	8.8
12029	Subsoil of 12028	Fine sandy loam, 36 to 72 inches.	.2	3.1	2.1	13.8	22.3	47.7	10.5
11993	Subsoil of 11992	Fine sandy loam, 12 to 72 inches.	.1	1.1	1.9	22.5	22.0	38.9	12.8

SACRAMENTO SILT LOAM.

The Sacramento silt loam, another important type of the area, consists of about 3 feet of moderately heavy silt loam, underlain by a brown or dark-colored clay loam, or by lighter sediments. The soil is of a very fine, smooth texture, somewhat micaceous, very sticky, and apt to puddle when wet, but of a loose, friable structure when in proper condition, and of impalpable and powdery texture when thoroughly dry. The surface foot is of a light-brown color, sometimes grading to black at about 18 inches. As in the Fresno fine sand, the depth of soil and the character of the underlying material are subject to great variation.

The main bodies of this soil type occur upon the north side of the American River, near the city of Sacramento, and also adjacent to the Bear River. Smaller irregular bodies occur in the vicinity of the American Basin and throughout the lower valley plain. The larger areas occupy portions of the lower river bottom lands and are subject to frequent overflow during flood periods. The smaller bodies occur as slight depressions in the valley plain or as irregular streaks and patches adjacent to or near minor stream channels crossing the lower valley slopes. The surface is level, except for occasional minor terrace lines or irregularities caused by unequal deposition or erosion, is without gravel, and in the case of large bodies adjacent to streams is often covered with a dense growth of cottonwood, willow, and brush.

The areas of Sacramento silt loam frequently lie below the level of the adjacent stream beds, and because of this and the rather close and dense structure of the subsoil, especially of the heavier phases, they are in many places wet and poorly drained during and following flood periods. When underlain by lighter sediments, however, the natural condition is improved, and the soil drains rapidly after the floods subside. The protection of these lands by levees, owing to the character of the floods and to the constant filling of the stream beds by " slickens " or mining débris, is often very difficult and costly. When overflow is successfully prevented the filling of the soil by seepage waters from the higher stream beds often takes place. Notwithstanding these unfavorable conditions, the soil becomes available for summer and fall crops.

The origin of the material composing this type is similar to that of the preceding alluvial soils, it being merely of a finer texture, deposited along stream flood plains and in depressions by slack silt-laden waters. As in the Fresno fine sand, small amounts of the common alkali salts sometimes occur near the surface, but this condition has not assumed serious proportions and is unlikely to do so.

Alfalfa, fruits, and berries requiring deep and moderately heavy soil do well on this type of soil when protected from floods. The soil is especially well adapted to beans and other vegetables, sugar beets, potatoes, and, when underlain by the lighter subsoils, to hops. Of these crops, beans and truck are grown upon the heavier phases of the soil, while the smaller bodies occurring upon the valley plain are generally devoted to grazing and to the production of grains. In the vicinity of Bear River small fields of alfalfa are seen, and upon the north side of this river, where the soil is generally underlain by fine sands and fine sandy loams, hops are extensively grown, the yields being heavy and of excellent quality.

and subsoil of the Sacramento silt loam are given in the following table:

Mechanical analyses of Sacramento silt loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
11994	3 miles NE. of Sacramento.	Brown silty loam, 0 to 12 inches.	0.0	0.2	0.2	4.7	13.9	64.7	16.2
12030	1¼ miles N. of Sacramento.	Yellow silty loam, 0 to 12 inches.	.0	.2	.6	2.5	5.4	72.0	19.0
12031	Subsoil of 12030..	Heavy silty loam, 12 to 72 inches.	.0	.4	.2	2.8	10.2	66.0	20.0
11995	Subsoil of 11994..	Brown clay loam, 12 to 36 inches.	Tr.	2.3	2.5	6.8	8.0	45.3	34.8

RIVERWASH.

The Riverwash consists of coarse, loose materials, varying from sand to cobbles and small bowlders, all the particles being generally well rounded. In this area the coarse sands and fine gravel predominate.

This type is found chiefly in the vicinity of Bear River and occurs as small narrow bodies following the courses of the streams in the foothills and plains regions. It occupies the beds and lower terraces of these streams and is subject to overflow during flood periods.

The material represents the coarser grades of mountain waste, augmented by mining débris, and is deposited from rapidly moving waters of streams in flood.

Owing to position and to texture it is unsuited to the production of any crop.

FRESNO RED SAND.

The Fresno red sand, to a depth of about 18 inches, is a coarse gray to dark-brown sand or sandy loam. This material is underlain by a red sandy loam, also of coarse texture, grading into red sandy adobe and red sandy hardpan. The soil in its natural condition is rather compact, but upon cultivation assumes a loose, porous structure.

This type occurs only in a few small bodies of irregular shape in the vicinity of Fairoaks and Orangevale. It occupies the summits of the higher ridges and undulations of the upper valley margins, and is unmarked by rock outcrop or gravel areas. Owing to the sloping surface, elevated position, and open porous structure, the soil is naturally well drained.

The origin of this soil is less obvious than that of the alluvial soils previously described. It was probably formed from materials derived from the adjacent granitic rocks, intermingled with the wash from the diabase, amphibolite, and volcanic rocks found in the region. The materials were probably distributed by ancient streams or by the waters of the ancient Pleistocene lake or bay.

While the soil is of open, porous structure and well drained, the heavy subsoil is capable of absorbing and retaining large amounts of moisture. The surface upon cultivation breaks into a loose mulch, greatly retarding evaporation. The underlying hardpan is generally found at such a depth as not to interfere greatly with the growth of trees when well irrigated.

The Fresno red sand is best adapted to the growing of citrus and stone fruits, vines, and early truck crops under irrigation. Although it is quite limited in extent it is one of the most important fruit-producing soils of the Sacramento area, and generally outranks the surrounding San Joaquin sandy loam. Peaches, plums, cherries, apricots, olives, oranges, and other fruits are grown with success.

The results of mechanical analyses of soil and subsoil of the type are shown in the following table:

Mechanical analyses of Fresno red sand.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
11999	Orangevale	Gray coarse sand, 0 to 16 inches.	5.4	34.8	15.7	16.9	6.1	10.9	9.7
11997	2 miles W. of Orangevale.	Dark coarse sandy loam, 0 to 18 inches.	2.3	16.7	11.5	26.7	11.5	18.4	12.2
12000	Subsoil of 11999	Red sandy loam, 16 to 36 inches.	4.2	34.3	12.5	15.7	6.1	14.1	12.9
11998	Subsoil of 11997	Red sticky sandy loam, 18 to 36 inches.	4.5	31.2	11.1	12.3	4.6	9.5	26.7

SALINAS GRAY ADOBE.

The Salinas gray adobe, like many other adobe soils, is subject to many variations. As typically developed it is a dark-gray to nearly black heavy adobe, with the texture of a clay loam. It often carries coarse, white, angular rock particles, and sometimes considerable fine to rather coarse sand. It ranges in depth from 4 to 6 feet, and is underlain by sand and clay beds, or volcanic mud flows.

The type occurs as irregular bodies along the upper valley margins and base of the foothills, extending downward into the valley plain.

A phase of the type also occurs over a portion of the lower valley plain, and will be described separately. The most typical areas occur mainly south and east of Lincoln, in the vicinity of Rocklin, and in the southern part of the area surveyed. They occupy the slopes of rolling, domelike ridges, or flat-topped table-lands, extending downward and covering the trough of minor drainage depressions and sinks. The surface of the higher slopes is sometimes broken by outcrops of the underlying rock. Trees and shrubs of the valley margins sometimes appear, but only as scattered specimens. The higher slopes are sometimes marked by occasional springs and marshy or boggy spots. The soil is extremely sticky when wet, and is capable of absorbing large quantities of water. The soil of both the upper and lower slopes is likely to become soft and boggy during rainy periods. Many of these small wet patches might be greatly improved by artificial drainage.

The exact origin of this adobe soil is not well understood; in fact, the same soil may apparently be duplicated under a variety of dissimilar conditions of mineralogical origin and mode of formation. Both residual and alluvial phases of this soil occur with but little apparent difference in texture, structure, or agricultural value. Typically, however, the Salinas gray adobe of the Sacramento area results from the weathering and breaking down of interstratified beds of clay, sand, and volcanic muds laid down under Pleistocene waters. This material has since been distributed and modified by stream wash, being subjected at the same time to a more complete decomposition and changed by the addition of organic matter.

Owing to heavy texture and peculiar structure, this soil is readily puddled, baking upon exposure, and checking into large, roughly hexagonal blocks, or sometimes into small cubical fragments. When wet, cultivation is very difficult and attended with the risk of rendering the soil still more refractory. If intelligently handled, however, both the soil and subsoil, by reason of their moisture-retaining properties, become an excellent medium for the maintenance of the moisture supply.

This soil is generally unirrigated, and is adapted to grazing and to the raising of grains and hay. With irrigation and drainage, good yields of corn, root crops, sorghum, and other forage crops should be obtained. The type is used chiefly as pasture for sheep and other stock, or dry farmed to grains and hay, the yields being good under favorable conditions.

The valley phase of the Salinas gray adobe consists of about 3 feet of heavy, compact, silty to clayey adobe, gray to black in color, underlain by a sandy adobe or sandy loam, the latter occasionally containing a large amount of marl or lime. The underlying material varies greatly and sometimes grades into the red sandy hardpan. This phase occurs as numerous irregular bodies throughout the valley plain, generally occupying local drainage depressions or sinks. In drainage features it is similar to the upland areas of this type.

Unlike the typical Salinas gray adobe, the phase is of alluvial or colluvial origin, the material being washed by flood waters from the uplands adobe, augmented by fine sediments washed from the soils of the plains.

In mineral and chemical properties and adaptation to crops it is similar to the upland soil of this area. The following table shows the results of mechanical analyses of both soil and subsoil of the Salinas gray adobe:

Mechanical analyses of Salinas gray adobe.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12002	8 miles S. of White Rock.	Gray clay loam, 0 to 12 inches.	0.8	2.8	3.0	11.5	10.2	42.4	29.2
12004	3 miles N. of Sacramento.	Gray heavy clay, 0 to 12 inches.	.3	2.4	2.1	5.5	6.5	40.6	42.4
12003	Subsoil of 12002	Clay loam, 12 to 72 inches.	.6	2.3	2.1	8.3	10.3	37.8	38.6
12005	Subsoil of 12004	Black heavy clay, 12 to 36 inches.	.3	2.7	2.2	5.3	6.0	31.1	52.1

ROUGH STONY LAND.

The Rough stony land consists of areas possessing a rather shallow soil, and where the bed rock outcrops excessively. The soil varies in color from a gray or drab-colored loam to a dark-red heavy loam.

A large body of the type, nearly 1 mile in width, begins about 1 mile southeast of Folsom City and extends in a southeasterly direction across the area. Portions of the type occupy high rolling hills and precipitous slopes of the higher foothills, some being extremely rough and almost inaccessible, and covered with angular bowlders, rock outcrop, and a dense and nearly impenetrable growth of chaparral or brush. The surface of large areas occurring upon the rolling and generally treeless ridges of the lower foothills is marked by frequent outcrop, usually appearing as peculiar flat, sharp, jagged projections following the trend of the ridges. Here the soil ranges from 6 inches to 2 feet in depth, seldom becoming deeper except in rifts in the almost vertically tilted rock.

The soil of the Rough stony land is residual in origin. Owing to its general shallowness and the prevalence of outcropping ledges cultivation is well-nigh impossible, and except for the growth of native vegetation available for grazing purposes the type has no agricultural value.

The following table gives the results of mechanical analyses of the fine earth of this soil type:

Mechanical analyses of Rough stony land.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12046	7 miles W. of White Rock.	Gray loam, 0 to 12 inches.	14.4	21.9	6.4	11.8	5.1	18.2	22.2
12047	Subsoil of 12046......	Gray loam, 12 to 24 inches.	7.8	14.6	6.3	14.7	9.7	25.1	21.8

SIERRA STONY LOAM.

The Sierra stony loam consists of a heavy loam of fine, smooth texture, varying in color from light red to dark brown or nearly black. It ranges in depth from 6 to 30 inches, the average being about 18 inches, and is underlain by volcanic gravels, muds, and breccias. The surface is generally gravelly and strewn with rounded cobbles and bowlders of volcanic andesite rock.

This type occurs in one large and many small bodies of very irregular outline, in the central part of the area, in the vicinity of Lincoln, Auburn, Newcastle, Rocklin, Roseville, and Folsom City. It occupies the summits of the flat-topped volcanic ridges and knobs which form a characteristic physiographic feature of the central lower foothill belt. The surface is nearly level or moderately sloping, thickly strewn with bowlders, and generally treeless, although sometimes a sparse growth of gray-leaf pine and other trees and shrubs of the foothills occurs.

Although occupying an elevated position, this type of soil is somewhat poorly drained, owing to the heavy texture of the soil and the usual flat, level character of the surface, and the fact that it is underlain at shallow depths by impervious material. The soil dries out slowly after heavy rains, and springs often appear along the foot of the slopes and the margins of the soil areas. Like all the soils of the Sierra series, it is residual in origin, being formed by the slow disintegration and decomposition of andesitic bowlders and the underlying volcanic muds and breccias.

surface, the Sierra stony loam is devoted or
it is of considerable value during the winter

The following table shows the results o
the fine earth of the soil and subsoil of this

Mechanical analyses of Sierra s

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.
			P. ct.
12035	¼ mile W. of Lincoln.	Dark-red loam, 0 to 15 inches.	2.9
12032	1¼ miles E. of Roseville.	Brown loam, 0 to 15 inches	8.1
12034	1¼ miles E. of Roseville.	Red heavy loam, 0 to 12 inches.	4.8
12033	Subsoil of 12032	Red stony loam, 15 to 21 inches.	9.6

SIERRA SANDY LOAM.

The Sierra sandy loam is subject to consi
ture, color, and depth. The typical soil, t
feet, consists of a coarse sandy loam of a lig
taining an abundance of fine, angular, ligh
or fine gravel. While the soil is sometimes
more than 6 feet in depth. It is underlain
plastic, sandy adobe similar to the overlyi
heavier texture and grading into granitic r

It is one of the most extensive and im
foothills region. The main body of the ty
northeastern part of the area, lying betwe
Auburn, and Folsom City. It usually cov
slopes of the lower foothills. While some
they are seldom so much so as to prevent
lying rock frequently outcrops as ledges or
well rounded by erosion. The slopes are co
and trees of the lower foothills.

Occasionally the rock outcrop predomina
so precipitous as to render the lands of but
this condition being most noticeable in the
the North Fork of the American River, an
the extreme northeastern part of the surve

The Sierra sandy loam is generally well drained; some minor depressions, springs, and swampy spots, however, would be greatly benefited by artificial drainage. The soil is the direct result of the disintegration and breaking down in place of the outcropping and underlying granodiorite rock. While chipping and breaking down into fragments rapidly, the rock is only slowly decomposed, the resulting soil being due rather to physical than to chemical agencies.

Like the other soils of the Sierra series, the Sierra sandy loam does not contain injurious quantities of alkali salts. It is splendidly adapted to the growing of berries, vines, citrus and deciduous fruits. suited to the climatic conditions of this area. Peaches, plums, cherries, apricots, pears, grapes, figs, oranges, strawberries, bramble berries, and other staple fruits of the foothill belt are grown in great quantities.

The dark phase of the Sierra sandy loam is of a finer texture, lacking much of the coarse, angular material of the typical soil, and grading from dark gray to nearly black in color. This phase occurs along the eastern margin of the main body of the type and adjacent to the neighboring amphibolite and diabase rocks.

It differs from the typical soil mainly in that it has a darker color, finer texture, poorer drainage, and in carrying a greater proportion of hornblende and diorite mica particles.

The following table shows the results of mechanical analyses of the fine earth of both soil and subsoil of this type:

Mechanical analyses of Sierra sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12036	1 mile W. of Roseville.	Coarse sandy loam, 0 to 12 inches.	14.6	26.8	11.6	18.4	6.2	12.9	8.9
12039	1 mile S. of Newcastle.	Coarse sandy loam, 0 to 12 inches.	11.4	20.3	8.5	16.8	8.6	17.2	16.7
12037	Subsoil of 12036	Coarse sandy loam, 12 to 30 inches.	13.2	25.5	11.9	18.3	7.2	12.5	11.1
12040	Subsoil of 12039	Coarse sticky sandy loam, 12 to 72 inches.	10.1	18.4	7.4	13.6	6.8	15.9	27.3

SHERIDAN SANDY LOAM.

The Sheridan sandy loam is somewhat similar to the dark phase of the Sierra sandy loam. It consists of a black friable sandy loam

of medium texture. In places the soil is ver
cases it greatly exceeds the average depth, wl
is underlain by granite rocks.

This is relatively an unimportant type,
small areas in the extreme northern part of t
the lower valley slopes of the foothills adjacer
ing valley margins, and extends into the loca
The native vegetation consists of the usual s
lower foothills. Outcropping masses of ro
quently occur. Natural drainage is facilitat
character of the soil. Its topographic positioı
less favorable, springs and poorly drained sp
lower slopes and in depressions.

The Sheridan sandy loam is of residual or
ing from the weathering of dark-colored, fine-
brodiorite and granodiorite rock. The mate
areas has been washed from the slopes and sı
alluvial material. A characteristic feature o
proportion of black hornblende and biotite n
plates and particles of which give rise to the

When well drained the Sheridan sandy loa
hay, forage crops, and fruit. The first thre
present. The areas also furnish good pastura

In the vicinity of drainage depressions, allı
occur. Here the soil is often 6 feet or moı
quently underlain by stream gravels. In all
similar to the typical upland soil, except that
depth it is frequently better adapted to agricı

The results of mechanical analyses of the
and subsoil of the Sheridan sandy loam are
table:

Mechanical analyses of Sheridan sa

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.
			P. ct.
12045	5 miles E. of Sheridan.	Sandy loam, 0 to 18 inches.	1.4
12043	7 miles N. of Lincoln.	Coarse sandy loam, 0 to 12 inches.	3.7
12044	Subsoil of 12043	Coarse sandy loam, 12 to 36 inches.	4.4

SIERRA CLAY LOAM.

The Sierra clay loam is a heavy loam of smooth, silty texture, often gravelly, and varying from a light-red to a very deep-red color. In depth of soil it varies greatly, but the average depth is probably about 3 feet. When dry the soil is moderately friable, and when wet becomes sticky and tenacious. It is underlain by bed rock. The gravel usually consists of flat shaly chips and rock fragments.

The Sierra clay loam is the prevailing soil type of the foothill region, and in extent of area devoted to important horticultural and agricultural interests ranks next to the Sierra sandy loam. It is extensively developed in the Sacramento area, where it stretches in one broad unbroken body along the eastern boundary, from the southern to the northern limits of the survey. At the north the same broad belt reaches more than half way across the area.

It occupies the slopes of the higher foothills, and in the northern part of the area surveyed and southward from Folsom City extends downward to the valley margin. In eroded districts, particularly in the vicinity of canyons and gorges, the surface is sometimes very steep, but moderate and more easily accessible slopes predominate. In general, the ridges are higher and the slopes steeper than those of the main body of the Sierra sandy loam. Bowlders and outcropping ledges and rock masses of subangular and only partially eroded contour frequently occur. The outcropping ledges become excessive over much of the southeastern portion of the area surveyed. In this section the slopes, owing largely to the shallow soil, are treeless and unproductive. Upon the deeper areas the vegetation of the intermediate and higher foothills prevails, consisting mainly of oaks, gray-leaf and yellow pines, and shrubs, consisting of ceanothus and coffeeberry.

The Sierra clay loam results from the weathering in place of the outcropping and underlying amphibolite, diabase, and limestone rock. The processes of rock decomposition are here generally well advanced, although the rocks are not weathered deeply. The diabase usually gives rise to a somewhat heavier soil of deeper red color than that derived from the amphibolite and limestone.

The soil is somewhat tenacious and readily absorbs water. Owing to topographic position, surface drainage is nevertheless rapid and general drainage conditions are good. Under proper cultivation the moisture-retaining properties are generally superior to those of the Sierra sandy loam. The soil, however, is not so easily cultivated, is often shallow, and possesses a slight tendency toward puddling when wet.

The deeper areas of this type of soil are well adapted to the production of grains, hay, grapes, and the usual deciduous fruits of the

lower and rocky areas are best adapted
Some of the deeper areas, under carefu
are capable of producing in favorable sea
wine grapes with little or no irrigatio
equal or, in some cases, superior to thos
Owing to soil texture and to topographic
reach maturity somewhat later than t
foothills.

The following table gives the results
the fine earth of typical samples of both s
clay loam:

Mechanical analyses of Si

No.	Locality.	Description.	Fine gravel, 2 to 1
			P.
12048	6 miles NW. of Auburn.	Red silty loam, 0 to 12 inches.	
12050	4½ miles NW. of Auburn.	Red heavy loam, 0 to 12 inches.	
12049	Subsoil of 12048......	Dark red loam, 12 to 40 inches.	
12051	Subsoil of 12050......	Red clay loam, 12 to 36 inches.	

SIERRA LOAM.

The Sierra loam is a heavy, dark-red lo
ing occasionally upon exposure, and ver
tendency to puddle if cultivated in th
depth from a few inches to several feet.
residual red adobe, and is underlain by
angular or subangular rock particles ofte
subsoil.

The Sierra loam is a relatively unimpo
limited areas in the vicinity of Pilot Hill
some of the slopes occupied are only ge
topography is rugged, some of the slope
ered with rough, irregular bowlders, ou
the chaparral growth of the more rugged

Owing to its heavy texture and struc
somewhat slowly drained, but this unfa

offset by the elevation and topographic features, which facilitate rapid surface drainage.

The soil originates from the disintegration and decomposition of the underlying and outcropping gabbrodiorite rock, which is very massive and breaks down under the influence of weathering slowly.

Owing to the frequent rock outcrop and shallow soil, large portions of the type are at best only suited to grazing. The deeper and smoother areas, however, when cleared of brush give good yields of hay and grain, and it is possible that successful grape and fruit culture might be carried on in a few of the more favored localities.

The results of mechanical analyses of the fine earth of both soil and subsoil of this type are shown in the following table:

Mechanical analyses of Sierra loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
12054	3 miles NE. of Clarksville.	Heavy loam, 0 to 12 inches.	7.5	14.6	7.6	16.8	9.6	23.5	20.1
12052	10 miles NE. of Folsom City.	Heavy loam, 0 to 15 inches.	4.5	12.3	6.5	15.5	10.9	27.3	22.2
12055	Subsoil of 12054	Loam, 12 to 36 inches	7.6	20.4	8.0	16.3	8.6	17.9	21.2
12053	Subsoil of 12052	Clay loam, 15 to 36 inches.	4.3	10.3	5.3	14.4	8.2	30.3	27.1

HARDPAN.

Except in areas of alluvial deposits near the larger streams, the occurrence of hardpan is general throughout the valley portion of the area. It is particularly well developed in those districts having the "hog wallow" mounds, which appear as a distinctive feature along the western margin of the survey. These mounds, however, are less prominent than those occurring in portions of the San Joaquin Valley, where hardpan is also found.[a]

The hardpan of the Sacramento area usually consists of red sandstone or clay-sandstone strata, from a few inches to a few feet in thickness, interstratified with layers of light-colored, compact or unconsolidated sand, gravel, partially disintegrated sandstone, or sandy or clayey adobes. The whole indurated system may extend to a depth of many feet, and is frequently exposed in cuts and bluffs, as along the American River at Fairoaks. It is usually encountered at a depth of from 2 to 4 feet, and upon the lower valley bottoms often lies much nearer the surface over extensive tracts, or is frequently exposed by superficial erosion.

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[a] See Soil Survey around Fresno, Cal. Field Operations, Bureau of Soils, 1900.

In the rolling valley slopes in the vicinity of the foothills it commonly lies deeper and is less continuous in character, and frequently outcrops as ledges along hillsides and ridges.

In the southwestern part of the area and south of the American River the strata seem to be generally less thick and dense. The material here and also in the vicinity of Fairoaks varies from the dense red sandstone of medium texture to a compact, white chalky material. The latter seems to be merely a very fine sediment compacted by pressure and having very little, if any, cementing material. The red material, however, is much more refractory and weathers very slowly upon exposure, the cementing material being principally hydrous silicates of iron. The hardpan strata are frequently separated from the overlying soil by a narrow zone of compact red adobe, frequently containing considerable sand or fine angular gravel.

An impervious hardpan of the character found in this area exerts a marked influence upon agriculture, and may render otherwise productive and favorably situated soils nearly or entirely useless for agricultural purposes. It limits the feeding ground of plants and confines the percolation of the rainfall to that part of the soil lying above the impervious stratum, with the result that the moisture finds its way to the surface to be lost by evaporation, and it cuts off the supply of moisture from the deeper soil.

Owing to the close approach to the surface of this material, large tracts of land lying north of Sacramento, on the opposite side of the American River, are used only for grazing purposes. Over the greater portion of the valley, however, grain and shallow-rooted crops may be profitably grown. Upon the higher rolling lands trees and vines are successfully grown, while southeast of Sacramento the culture of strawberries, grapes, and small fruits has become an established and profitable industry.

Tracts in which the material prevails nearer the surface than 2½ or 3 feet should be cultivated to shallow-rooted crops that either mature quickly before the advent of the hot, dry months, or that may be supplied with moisture by irrigation. In extreme cases blasting is sometimes restored to in loosening and breaking up the hardpan.

RECLAMATION OF SWAMP LANDS.

Large unbroken tracts of swamp and overflow land extend throughout the lower Sacramento and San Joaquin valleys. Very little typical swamp land occurs, however, within the limits of the area surveyed, and this consists of small irregular depressions, of insufficient drainage and subject to overflow, found chiefly in the lower

American River and Bear River bottoms. Small isolated tracts also occur in the lower foothills, caused frequently by obstruction of natural drainage through mining operations. An area of several hundred acres of overflowed land, known as the American Basin, lies about 4 miles north of Sacramento, along the Sacramento River. Much of this land is available for grazing purposes during the dry summer season.

Small swampy bodies upon the higher slopes and levels may be profitably reclaimed by a system of open or tile drains. The reclamation of the more extensive overflowed lands adjacent to the river courses can be effected only by constructing an elaborate and expensive system of levees and drainage channels.

WATER SUPPLY FOR IRRIGATION.

In the early days of agriculture in the Sacramento area irrigation was thought to be unnecessary, but when the growing of fruit began to assume importance along the foothills and in the river bottoms, experiments in a few orchards showed that the trees did much better and gave larger yields where water was used, and from this beginning the practice has spread, until irrigation, at least in fruit growing, has come to be regarded as a necessity.

The water used for irrigation purposes is derived both from the streams and from an underground supply. Of the streams, the American River furnishes the main supply, followed by the Bear and Yuba rivers. North Fork Ditch, extending from the North Fork of the American River some distance below Auburn, supplies much of the foothill fruit land lying north of Folsom City, and large tracts of the upper valley slopes in the vicinity of Orangevale and Fairoaks. The Natoma Ditch, tapping the same river, supplies large tracts of vineyard lands upon the south side of the river in the vicinity of Natoma. The main supply covering the foothill belt southward from the vicinity of Auburn is drawn from the Bear and Yuba rivers outside the limits of the area surveyed, and brought into the area through a single large canal entering at the northeastern corner. In addition to these large canals, there are a number of minor ditches deriving water from various streams and used as a supplementary supply. Many of the smaller and some of the larger canals were formerly used solely, and are still used partially, in mining operations.

In the vicinity of Fairoaks, Orangevale, and over part of the foothills region the water is distributed in underground pipes of various sizes, hydrants being placed upon the summits of knolls and ridges, from which the water is distributed in furrows. By this means all loss from seepage is prevented, and the canal and pipe lines being subject to rapid fall, the water is secured under pressure and brought to the higher elevations. This system, however, when it becomes inadequate to supply the demands, is enlarged with difficulty. Serious loss has already been experienced from an inadequate water supply, especially in the vicinity of Fairoaks, and a system with increased capacity is much needed at this point.

For the most part, with economical use and proper cultivation, the water supply of the foothill belt is sufficient for the present needs, but the further extension of irrigation to large tracts of unimproved land of the lower foothills and upper valley slopes adapted to fruit culture will necessitate an enlargement of all these systems. The streams forming the source of supply carry during flood seasons enormous quantities of water, but during the dry season the supply is limited. The supply can be greatly increased by the construction of additional canals, supplemented by reservoirs. In the Sierra foothills such work is attended with great cost, and further development of the systems will take place rather slowly and only to supply real and immediate needs.

Lying south of the American River and extending southwest from Natoma to the limits of the area, is an important belt devoted to intensive agriculture, which is irrigated mainly with water from an underground source. In the vicinity of the American River the wells are frequently sunk to a depth of from 100 to 150 feet, and are fitted with centrifugal pumps driven by gasoline, steam, or electric power. In the vicinity of Perkins and extending southward across the area, a great number of small tracts devoted to the culture of strawberries, grapes, and small fruits, are successfully irrigated by windmills, the water-bearing strata lying usually from 10 to 25 feet below the surface. Small power plants operated by gasoline, steam, or electricity are here also in use. This source of supply is capable of further development and for small tracts is fairly efficient and satisfactory.

The water used for irrigation purposes in the Sacramento area, whether derived from streams or from underground sources, is of good quality.

DRAINAGE OF SOILS.

Throughout the foothill belt and valley plain occur many small patches of poorly drained land. These are usually kept wet by springs and ravine channels supplied by natural rainfall, and are more extensive during and after the winter rains. While each usually covers only a few rods or a few acres, in the aggregate they constitute a considerable body of land. Ditches, or preferably tile-drains, would in many cases remove the excess water and prove a profitable investment, especially when such areas. as is often the case, occur in the orchard lands of the foothills.

Draintile is manufactured in large quantities at Lincoln, within the area surveyed, and should be procured at moderate prices. In the vicinity of the valley trough larger areas of deficient drainage occur, which might be greatly improved by a more extensive drainage system. These lands are, however, devoted to grain growing and warrant less expenditure, but even here, in at least many cases, the investment should prove profitable.

ALKALI IN SOILS.

The presence of alkali salts in the soils of the Sacramento area is favored by the chemical composition of the rocks from which many of the soils are derived. However, good natural drainage, coupled with a moderately heavy rainfall, as compared to other areas surveyed in California, offsets this tendency, and the soils of the area may be said to be free from alkali salts in unusual or harmful amounts. There are, however, throughout the lower valley trough and in the vicinity of the American River bottoms near Sacramento a few small, low-lying tracts in which there is a slight accumulation of the salts.

While little or no injury has as yet been experienced by alkali in this area, a more general and abundant irrigation might, by increasing capillary action and evaporation, give rise to danger upon unfavorably situated tracts. Usually the soils in which these salts have already appeared in slight amounts are of loose, open texture, and no serious trouble is apprehended. Should alkali salts occur in harmful amounts, a few underground drains and an occasional flooding would soon remove them and thereafter keep the accumulation under control.

AGRICULTURAL METHODS.

Owing to pronounced variation in topography, soils, irrigation facilities, and to the cosmopolitan character of the agricultural classes, the agricultural methods in use are quite varied. Throughout the portion of the area devoted to the growing of grain the preparation of the land is in general inadequate. Plowing, almost without exception, is done by steel gang plows and is often shallow, although it is usually more thorough than in many other grain-growing districts of the west. The land usually receives only one plowing every two or three years. The soil is given only a light harrowing or is sown without preparation other than plowing. Summer fallowing is practiced almost without exception, the land remaining idle every second year. The soil when wet is of peculiar character, running together and baking hard upon exposure, and is rendered almost useless if worked when wet. This fact, in connection with seasonal climatic conditions, greatly interferes with cultivation and annual cropping. During the fall of the second year the seed for another crop is sown upon the unplowed stubble land and covered with an ordinary or disk harrow. The land is at this time very hard and dry, and if plowing is attempted it results only in the formation of a mass of hard, dry clods. The seed bed for the second crop is necessarily very incompletely prepared, and the yield is usually much lighter than that secured when the field is plowed. After the removal of the second crop the land is again plowed in the following spring and left during the summer as fallow land. Under this system only a portion of the land is at any one time producing crops, and conditions favoring full crops are usually obtained only once in three years. The grain is grown entirely without the aid of irrigation and is harvested by the use of modern labor-saving machinery. No commercial fertilizer and very little barnyard or stable manure is used upon these lands, although the crop yields are decreasing. A more liberal application of barnyard or stable manure and the use of green manures would undoubtedly improve the soil structure, as well as add organic matter—a much needed constituent. There seems to be no leguminous crop, however, adapted to the climatic conditions that can be grown upon these shallow soils without the aid of irrigation. The growing of alfalfa and other deep-rooted crops, which might be used in rotation with grains, is greatly restricted by the presence of the hardpan strata or underlying rocks near the surface.

On the intensively cultivated tracts devoted to orchards and vineyards the preparation and subsequent cultivation of the land are much more thorough and effective. The frequency of irrigation varies with the topography, the kind of soils, and the individual practice of the grower. With some orchards little or no irrigation is practiced until the trees come into bearing, and upon some of the heavier moisture-retaining loams grapes are successfully grown without the aid of irrigation. With the better class of fruit growers the importance of thorough and frequent cultivation of the soil during the summer season is generally recognized. The soils of the area usually possess remarkable power to retain moisture, and the practice of frequent cultivation of the soil to prevent evaporation is very effective in carrying the trees and vines through the long summer droughts. Commercial fertilizer is used only to a limited extent. Green manuring with alfalfa and clover is not at all general. This practice, as well as the use of barnyard and stable manures, is recommended. The growing of alfalfa is, however, sometimes difficult on the shallow residual soils.

The growing of berries, asparagus, hops, vegetables, and other special crops is conducted along scientific and intensive lines. In strawberry culture the land, which is well adapted to this particular fruit, but of only nominal value for general farm purposes or deep-rooted crops, is first leveled and furrowed, the furrows being usually 3½ feet apart. The plants are set out along the furrow edges, and, forming beds between, are watered by subirrigation from the furrows. Bramble fruits and grapes are sometimes planted between the vines to replace the berry plants which at the end of four or five years usually become unproductive. The soil being underlain by the impervious hardpan, there is but little loss of water from seepage, and the system with proper means of irrigation is very successful.

Hops are grown upon permanent overhead wires or trellises, placed about 20 feet above the ground and supported by heavy posts. Asparagus is cultivated in the vicinity of Sacramento, and the early marketing of this product is said to bring handsome profits. Asparagus, beans, and other truck crops grown along the lower bottoms of the American River need little irrigation, the less favorably situated lands being supplied with small gasoline or steam pumping plants.

The dairying and stock industries, owing to natural advantages of climate and growing demands for their products, are increasing in importance. Large tracts of land lying along the lower valley plain and in the rocky and rugged southeastern portion of the area are well adapted to these industries. The native grasses are rich and nutritious. During the summer season dairy herds are commonly driven to the mountains and returned to the area in the fall. Upon the fine and deep river sediments alfalfa may be successfully grown. The quality of stock and methods for handling the output have in the past been somewhat unsatisfactory. The introduction of a better grade of stock and more modern appliances for the manufacture of dairy products would insure greater success. The raising of a limited number of mutton sheep in connection with grain and hay is to be recommneded. Small flocks can be grazed upon the hay and grain stubble lands during the most of the summer season. Upon the brush and grass covered slopes of the foothills, also, the raising of goats and sheep could be made profitable.

Upon the whole, the methods in use may be regarded as suited to the soils and conditions of the area. The advantages of thorough preparation and cultivation of the soils, however, should be more generally recognized, and the gradual adoption of a more diversified and intensive farming system on some of the extensive tracts is recommended.

AGRICULTURAL CONDITIONS.

The farming class in this area have met with failure as well as success upon both the extensive grain-producing tracts and the small farms devoted to intensive agriculture. In many ways, however, natural conditions favor success rather than failure. The area is free from vexing alkali and seepage water problems. The winter rainfall is sufficient, with careful and thorough cultivation, to mature many crops without the aid of irrigation, and dry farming grain and hay is always certain to meet with at least partial success, there being no total failures, as is often the case under more arid conditions. With the exception of the pear blight, which threatens the pear industry, there are no unusual or dangerous plant diseases or insect pests. Citrus fruits are remarkably free from smut or scale and require but little preparation for packing.

The intensively cultivated districts have usually the appearance of prosperity and thrift. An unusual number of neat farm buildings are found here, the absence of which is often noted upon the extensively farmed tracts. Churches, schools, and other means for intellectual, moral, and social improvement are liberally provided. This condition is noted especially in the vicinity of the main foothill fruit belt and in sections devoted to the production of special crops. Neat, well-regulated towns and shipping points occur at frequent intervals. In the mining, grain, and grazing sections, however, the conditions are less satisfactory.

While the agricultural classes are in general prosperous, mortgaged lands and homes are not uncommon. Orchard and vineyard lands and those devoted to the growing of special crops are generally farmed by the individual owners, although renting of such lands is sometimes practiced. The proportion of rented land is greater in the regions devoted to grazing and to the growing of berries, vegetables, grain, and hay. According to the census of 1900 less than 50 per cent of the farms of Sacramento County were operated by their owners. The percentage is probably greater within the limits of the area surveyed, which includes portions of the counties of Sacramento, Placer, Eldorado, and Sutter. The grain, hay, and grazing tracts are rented to tenants either for cash or for a part of the crop.

While there are a few large orchards, vineyards, and hopyards operated by a single individual or corporate owners, the most of these products are grown in small tracts. The grain, grain-hay, and stock-raising lands are, however, generally held in extensive tracts or ranches, in many cases the remnants of former Spanish or Mexican land grants. One tract alone, lying on the north side of the American River, near Sacramento, and devoted exclusively to the breeding of trotting and thoroughbred horses, covers an area of about 60 square miles. Owing to these extensive holdings, and notwithstanding the great number of small orchard, vineyard, berry, and vegetable farms, the average sized farm in Sacramento County according to the last census is 480.2 acres.

The handling of teams and machinery upon the extensive grain-producing lands is done almost exclusively by white labor. Much of the labor in picking, packing, drying, and canning the fruit is done by women and children and by Chinese and Japanese laborers. Frequently the unharvested crop is sold to Chinese or Japanese speculators, who attend to the placing of the crop upon the market. Thousands of men, women, and children enter the area for employment and camp in temporary villages during the hop-picking season, which lasts during August and September.

Much of the labor engaged in the cultivation, harvesting, and marketing of asparagus and truck crops is Chinese and Japanese, although the greater part of such crops is produced by Portuguese and Italians, who usually own or rent small tracts, and by cooperating, as is often the case, perform most of the labor themselves.

In the valley portion of the area wheat, oats, barley, and grain hay are the principal crops. Wheat is the most important grain crop, and is usually sown from the middle of October to the middle of December and harvested in June and July. In the foothills, upper valley slopes, and part of the valley plain lying immediately south of the American River, table and wine grapes, peaches, plums, cherries, pears, apricots, prunes, figs, and other deciduous as well as citrus fruits are produced in large quantities. The leading varieties of table grapes are the celebrated Flame Tokays, Muscats, Black Prince, Morocco, and Cornichon. Wineries and distilleries at Sacramento and other points in the grape-producing sections make large quantities of wine, consisting chiefly of port, sherry, angelica, claret, and brandies.

The growing of peaches of an excellent quality has been one of the most profitable and popular industries of the middle and lower foothills zone. Pears are of many varieties, the most popular being the Bartlett. Olives, both for preserving and for the oil, are grown quite extensively in the vicinity of Fairoaks and Auburn, and at other minor points. The Smyrna fig has been introduced and grown to a limited extent. Citrus fruits are grown chiefly in the vicinity of Rocklin, Valley View, Loomis, Penryn, Orangevale, and Fairoaks, but this industry is overshadowed by the grape and deciduous fruit interests.

In the vicinity of the Bear River, in the northwestern corner of the area, and of the American River, in the southwest, hop raising is conducted upon a large scale. In the berry and small fruit district, lying to the southward of the last-mentioned district, strawberries, Tokay and other table grapes, and bramble fruits are the principal crops. Asparagus, beans, tomatoes, cabbages, onions, melons, and potatoes are also important crops in the area.

The principal fruit packing and shipping points are Newcastle, Sacramento, Penryn, Loomis, Auburn, Orangevale, Fairoaks, Rocklin, Folsom City, Lincoln, and Roseville. A large proportion of the fruits, asparagus, tomatoes, beans, and other ve canneries at Sacramento and at outlying point:

The adaptation of soils of certain texture a: crops is usually recognized and taken advai intensively cultivated districts. Upon the sl lands of the valley plains, grain growing ha: industry, because the soil is peculiarly adapt to a few other crops. The compact and ad the moisture from the winter rains until the Dry farming to grain upon a loose, porous, would probably result in failure. The rich va depth, deep alluvial sediments, and well-drair upper valley margins are selected for the pr vines. Hops, beans, asparagus, and other truck the fine sandy loams and the deep moist alluvi

In the more thickly settled valley and foothi roads are usually well graded and maintained In the vicinity of the grain growing, mining, however, there is need for better roads. Witl furnished by mountain and foothill streams, the construction of rural electric railway line settled districts. Three lines of the Southern P the area—the Sacramento and Placerville lin line, and the Oregon line leaving the main li of the fruit goes over the main line to the East rates are high the shipping accommodation: In addition to the railway facilities, much bul of hay, vegetables, and potatoes, is shipped c from Sacramento to San Francisco and surrou

Besides the local markets, San Francisco a furnish excellent markets for early fruits, meat and dairy products. Eastern and European of the fruits, while the opening of oriental and Far East creates a demand for vast quantitie mutton, dairy products, and fruits, which a ports of the Pacific from San Francisco.

SOIL SURVEY OF THE BAKERSFIELD AREA, CALIFORNIA.

By MACY H. LAPHAM and CHARLES A. JENSEN.[a]

LOCATION AND BOUNDARIES OF THE AREA.

The Bakersfield area, with which this report deals, lies in the extreme southern or upper portion of the San Joaquin Valley.

Although small in extent, consisting of only about 200 square miles, the area surveyed includes nearly all the irrigated lands about the city of Bakersfield, and is representative of the lands of the San Joaquin Valley of this section of the State.

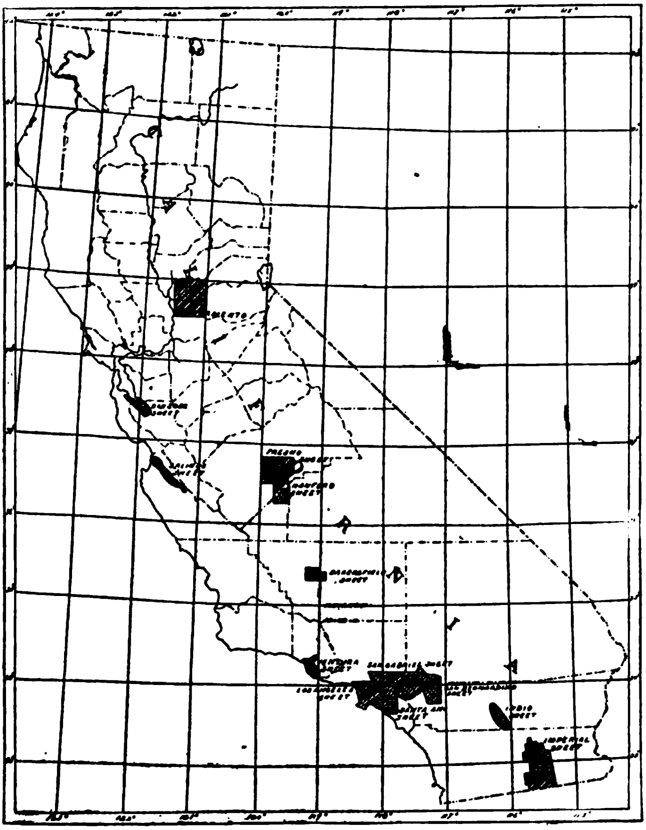

FIG. 44.—Sketch map showing location of the Bakersfield area, California.

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[a] The authors were assisted in the field work of this survey by Messrs. W. W. Mackie and A. T. Strahorn.

in the northeastern corner, the survey covers a rectangular area of six townships. Of this area the southern and central portions are most important from an agricultural standpoint. In addition to the farming lands, the area includes a relatively large extent of unirrigated lands, grazing lands, and alkali lands of nominal value.

To the north of the area mapped extends a great stretch of tillable land, capable of being rendered very valuable under irrigation. At one time a large area of this land was under cultivation, but it has now reverted nearly to its original desert condition, owing to the use of the limited water supply upon the more thickly settled districts of the Kern River Delta. To the west and south lie vast bodies of grazing lands, with here and there a small irrigated tract. These lands, while valuable to the beef-producing industry, are for the most part nonirrigable under the present conditions of water supply, and merge into the dry bed of Kern Lake and the swamp and desert lands of the valley trough. To the eastward of the area surveyed stretches a nearly barren desert. This desert land extends to the base of the mountains, and, with the exception of small, favorably situated tracts dry farmed to wheat, is in its present condition of little or no agricultural value.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

The early history of this region, like that of many other now important agricultural districts of the Southwest, is that of the desert—dry, barren, and desolate. To the south lay Kern and Buena Vista lakes, into which emptied the waters of the Kern River. From these lakes the overflow found its way through Buena Vista Slough and Swamp into Lake Tulare, some distance to the northward, said to have been at one time the largest body of fresh water west of the Rocky Mountains.

The first settlement of this part of California was made by the Mission fathers and by authority of Spanish land grants. Gradually the lands came to be recognized as of value for grazing purposes by the few settlers, chiefly of the Spanish or Mexican races. An abundance of game, consisting chiefly of antelope, elk, and wild fowl. ranged the plains or thronged the tule lands of the lakes and swamps. Droves of hogs and bands of horses, escaped from domestication, ran wild over the valley. As in many other sections of the State, grazing led slowly to the introduction of cereals and alfalfa as staple crops. This was made possible, however, only with the introduction of irrigation.

As early as 1864 the construction of artificial channels and the diversion of water from the Kern River for purposes of irrigation took place. These early efforts were only partially successful. Temporary headworks were swept away, water-ways were filled with débris, and old natural stream channels obliterated by the sudden and violent spring freshets. For several years diversion ditches were but small and temporary affairs, and the methods of irrigation were crude and primitive. Later on companies were formed for the construction and maintenance of more extensive and enduring systems. The construction of the Kern Island Canal—the earliest of the main canals of the present system covering the delta lands—took place during the period from 1870 to 1874. This canal is entitled to a priority of 300 second-feet over all others, has a carrying capacity of 500 second-feet, and with its branches cost about $200,000. The construction of additional systems covering other sections of the area followed, and the primitive means of applying water by "wild" flooding gave way to more exact and economical methods, while with these improvements a rapid rise in land values occurred and interest in the growing of alfalfa and other general farm crops increased.

For a time successful irrigation led the oversanguine to hope for much more than could be obtained from a limited water supply. Canal construction seemingly ran riot, and many thousands of dollars were invested in expensive systems under the Galloway and Beardsly canals and covering a large area of valley lands lying northwest of Bakersfield. Then a succession of dry seasons, coupled with the extension of irrigation upon the delta lands and the appropriation of almost the entire available water supply by those systems holding prior rights, led to failure and the abandonment of large tracts.

With the use of Kern River water for irrigation purposes, less and less found its way into Kern and Buena Vista lakes, while lands subject to occasional inundation were successfully diked, and thus many thousand acres were reclaimed for grazing and agricultural purposes. By the construction of an extensive system of levees the flood waters which occasionally found their way to the valley trough were confined in Buena Vista Lake, which now serves the purpose of a reservoir, with a capacity reckoned at 150,000 acre-feet. The outlet is by way of Buena Vista Slough and an artificial channel of the Kern Valley Water Company into Tulare Lake.

With the recent business activity and increase in population due to the development of mineral-oil interests, local markets offer increased inducements for the products of agriculture.

CLIMATE.

The weather records of the Bakersfield area are somewhat incomplete. The average annual rainfall, however, is about 5 inches, nearly all of which occurs during the rainy season. From November to

April is considered the rainy period, although the fall rains are often delayed until well into the winter, and the total annual precipitation is subject to considerable variation. The rain usually comes in gentle or steady showers, thunderstorms and cloudbursts being very rare, except in the mountains.

A table giving temperature and precipitation for the Bakersfield area follows.

Normal monthly and annual temperature and precipitation.

Month.	Bakersfield.		Month.	Bakersfield.	
	Temperature.	Precipitation.		Temperature.	Precipitation.
	° *F.*	*Inches.*		° *F.*	*Inches.*
January	48.1	1.11	August	84.7	0.01
February	52.4	.51	September	75.8	.13
March	57.9	.93	October	66.0	.47
April	64.7	.22	November	55.9	.38
May	72.9	.18	December	48.2	.80
June	81.9	.05	Year	66.4	4.81
July	88.6	.02			

During the winter and early spring months the days frequently become quite warm, though sometimes followed by frosty nights. This unfortunate condition attending an otherwise subtropical climate renders the growing of citrus and other delicate fruits impossible, or at best a matter of great risk. During the dry summer months the temperature reaches a maximum exceeded in but few localities within the boundaries of the United States. The extreme degree of heat attained during the day is, however, greatly modified by the low relative humidity, and the heat is much less oppressive than the readings would indicate. Although temperatures ranging from 110° to 120° F. are experienced, sunstroke is almost unknown. The nights are generally cool and pleasant.

The low relative humidity is also important in its relation to evaporation. With the associated conditions of cloudless skies and high temperatures evaporation takes place very rapidly. The necessity of keeping soil surfaces shaded by a dense covering of crops, or covered by a loose mulch maintained by frequent cultivation, is a matter of more than ordinary importance in this area.

During the winter and spring months sudden dust storms and brisk winds frequently occur. During the summer period the prevailing winds are from the northeast and are light and steady in character.

The proportion of cloudy days is very small. During the dry season clouds are rarely seen. Fogs occur during the winter months, but are not always a prominent climatic feature.

Although malarial diseases sometimes prevail, owing, it is believed, largely to poor drainage conditions in portions of the area, the climate as a whole is healthful, and such as, with the aid of irrigation, to hasten a vigorous vegetable growth.

PHYSIOGRAPHY AND GEOLOGY.

One of the most striking features of California is the great central valley. Formed by the conjunction of the Sacramento and San Joaquin valleys, it extends in a northwesterly and southeasterly direction through the north-central portion of the State for a distance of some 400 miles. It is with the upper part of the southern or San Joaquin Valley that we are concerned.

In physiographic as in climatic features the San Joaquin Valley is remarkably uniform. Its eastern wall is formed by the Sierra Nevada Mountains, a range of unusually high peaks, snowy crests, precipitous slopes, deep canyons, heavy precipitation, dense forests, and important perennial streams. To the northeast of the area surveyed the mountain slopes become less precipitous and the altitude lower, merging into the ridges of the Tejon and San Emidio mountains and forming the semicircle inclosing the southern extremity of the valley. Although the summits are subject to considerable precipitation during the rainy season no streams of importance find their way to the valley.

Upon the west the Coast Range rises from the valley in a succession of rolling hills and ridges, usually reaching an altitude of from 2,000 to 4,000 feet. These are dissected by narrow canyons—the courses of intermittent streams that during the rainy season disappear upon the slopes below. No perennial streams having their sources in these ridges reach the valley trough. The Coast Range hills—rarely and only for short intervals covered with snow—hot, dry, and, save in the vicinity of stream courses, barren, are thus in striking contrast to the heavily forested, humid summits of the Sierras.

Formed by the melting snows and heavy rains of the mountains, torrents rush down the inclines and through the canyons, gathering as they go the soil and rock débris. When the slopes of less degree are reached the water spreads outward, and the velocity and transporting power of the stream is lessened, while the water sinks into the desert soil. The load of the débris is thus spread outward in gently sloping fanlike forms. This process many times repeated has resulted in the gradual coalescing of the numerous canyon fans, finally producing the valley plain with nearly smooth, uniform surface sloping slightly from the base of the mountains toward the valley trough.

Owing to the heavier precipitation and greater run-off, the débris removed from the Sierras greatly exceeds that carried away by the insignificant streams of the Coast Range, resulting in the formation of a much more extensive valley plain upon the east side, and the pushing to the westward of the valley trough or axial drainage depression. More recent distribution of the alluvial material by the larger perennial streams of the Sierras has in places resulted in the formation of extensive delta deposits overlying the valley plain.

Within the limits of the area surveyed the physiography is simple and without great topographic variety. To the north and east of Bakersfield gradually sloping mesa lands merge into rolling hills and gravelly bluffs cut by the channel of the Kern River. With increasing elevation these extend to the base of the mountains. South of a line drawn directly east from Bakersfield but little foothill or mesa land interposes between the valley plain and the mountain ranges.

At a point about 10 miles east of Bakersfield the Kern River, rising in the high Sierras, after following a southerly course for about 120 miles and presenting splendid natural resources for the development of water power, breaks through the lower ridges in a deep, narrow canyon. It then takes a westerly course between the gravelly bluffs of the mesa lands to a point near Bakersfield. Here the stream becomes wider and more shallow and threads its way through the delta lands to the lake basins lying to the southwest. Owing to the occurrence of warm rains and melting snows in the mountains, the stream is subject to sudden and violent floods during the spring and early summer. At such times the débris-carrying power of the river is greatly augmented. This has led to the obliteration of old channels and the formation of new, and left many sloughs, streaks, ridges, and spits of sandy land.

The delta land known locally as Kern Island extends, with a generally smooth, even surface and uniform slope—6 to 7 feet to the mile—southward and westward to the valley trough marked by Kern and Buena Vista lakes and the swamp lands connecting them with Tulare Lake to the north.

A considerable growth of cottonwood, willow, and sycamore frequently covers the lands bordering stream channels. Upon the soils to the north and east of the delta trees and shrubs are wanting, except for an occasional growth of saltbush and other characteristic bushes usually found on desert or alkali lands. A dense growth of a low-growing form of the prickly pear cactus covers the loose sands along the southeastern margin of the area, while grasses, including salt grass, foxtail, and erodium, cover considerable areas of the valley plains and delta lands utilized for grazing purposes.

The rocks of the Sierra Nevada Mountains, from which the soils of the Bakersfield area are derived, are chiefly granites. Associated with the granites and granitic rock of this range occur large areas of ancient metamorphic and secondary slates, amphibolites, sandstones, basalts, etc. It is probable, however, that the soils of the area are derived very largely from the disintegration of granitic rocks.

The rocks of the Coast Range are often subject to even greater variation in character and complexity of structure than those of the Sierras. The resulting soils are, however, found only upon the plains and delta lands of the western side of the valley trough and do not enter into the formation of the soils of the Bakersfield area.

The soils of the valley are very deep, without rock outcrops, gravel, or bowlders, and were probably laid down in the deep waters of an inland sea or arm of the Pacific once covering the valley.

Within the Bakersfield area recent colluvial material or mountain waste and the alluvial material of the Kern River Delta have formed a more or less superficial stratum overlying the original valley sediments. The thickness of this layer is greatest upon the mesa lands near the northeastern margin of the area. This material here consists of stratified deposits of coarse and fine sands, well-worn bowlders, and gravel, silts, and loams. A stratum of reddish-yellow coarse sandy adobe generally overlies these deposits. Owing to changes in level these materials, of which the greater part was originally laid down by the waters of the Kern River, have since been cut and terraced by the same stream.

Moderately fine waterworn gravel frequently covers the slopes of the mesas and hills.

Certain soil areas are marked by the occurrence of alkali carbonate hardpans, which are treated in a following chapter.

The soils of the delta grade from coarse and fine sands to heavy clay loams and silts. They are generally rich in micaceous material, and the heavy, poorly drained soils are frequently impregnated with the soluble alkali salts.

In the vicinity of the mesa lands north of the Kern River petroleum oils occur in great abundance and have given rise to a great oil-producing industry.

SOILS.

The soil types in the area surveyed may be roughly divided into two classes, according to their origin, viz, alluvial, or sedimentary, soils and colluvial soils. The alluvial soils are found in the Kern River delta, and consist of the Fresno fine sandy loam, Fresno fine sand, Oxnard silt loam, Riverwash, and a part of the Fresno sand. These types owe their origin chiefly to sedimentation from the Kern River.

The colluvial class is made up of the Maricopa sandy adobe, Placentia sandy loam, Maricopa loam, and the remaining part of the Fresno sand. The Maricopa loam also probably owes its origin partly to sedimentation from the Kern River.

No residual soils were found in the area. All the soils were correlated with types previously established.

The following table gives the extent of each of the types, while the accompanying soil map shows their distribution over the area:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Fresno sand	43,264	34.6	Maricopa sandy adobe	5,120	4.1
Fresno fine sand	33,920	27.2	Placentia sandy loam	4,928	3.9
Fresno fine sandy loam	28,744	19.0	Oxnard silt loam	1,664	1.3
Riverwash	6,464	5.2	Total	124,928	
Maricopa loam	5,824	4.7			

RIVERWASH.

The Riverwash consists of a few inches of fine sand, of the same texture as the Fresno fine sand, underlain to a depth of 6 feet by a loose, incoherent, generally coarse, micaceous sand. The surface coating of fine sand is absent from the dry stream beds.

The type is found chiefly along the Kern River, is level, and at the time of the survey was well drained and free from alkali.

It is sedimentary in origin, the fine sand coating having been deposited on the lands immediately adjoining the river during temporary overflows of that stream.

With the exception of small areas of this type in the extreme eastern part of the area, the Riverwash is not under cultivation, being used for grazing only.

FRESNO SAND.

Two phases of the Fresno sand are found in the area surveyed, but the distinction between them seems insufficient to warrant a separation into two types. These phases are a compact soil and one that is loose or only slightly coherent. The latter, or loose phase, consists of 6 feet of coarse, micaceous, yellowish sand containing appreciable quantities of clay, but not enough to make it sticky when wet. The compact phase generally consists of 6 feet of coarse, reddish, compact sand, often containing considerable clay, and less micaceous than the loose phase. It compacts well in roads, though easily tilled, and is sometimes underlain at 2 or 3 feet by about a foot of light sandy adobe, which is in turn underlain by loose sand. This phase of the Fresno sand grades into the Placentia sandy loam.

The largest areas of this type are located in the northern part of the area, but small strips are found scattered through its entire extent. It occurs on level plains, gentle slopes, and local, slightly elevated

ridges, also at times in small, narrow, sing
represent former stream channels.

The soil is well drained, occupying, as
elevations. It seldom contains injurious a
soluble salts are present they are usually
foot.

In origin the type is both colluvial and
case of the compact phase in the northern
derived chiefly from wash from the foothi
in the case of the loose phase deposited by
phases, however, grade so gradually into
esses of formation are often responsible f
type.

The principal crops grown are alfalfa
The soil is adapted to any crop suited to
the area.

The following table, giving mechanical
of the soil and subsoil, shows the texture o

Mechanical analyses of Fre

No.	Locality.	Description.	Gravel, 2 to 1
			P. c
10510	NW. cor. sec. 30, T. 29 S., R. 27 E.	Coarse sand, 0 to 72 inches	18.
10508	N. of W. cen. sec. 8, T. 29 S., R. 27 E.	Compact sand, 0 to 12 inches.	9.
10509	Subsoil of 10508	Compact sand, 12 to 72 inches.	13.

FRESNO FINE SAND

The Fresno fine sand is a yellowish mi
ing little coarse sand or grit. Its deptl
though perhaps more often it extends to
change. When of less depth, it is underlai
rarely with fine sandy loam, and rarely w
less than a square mile in the extreme n
area is underlain by heavy adobe or clay
feet.

The Fresno fine sand is quite generally
area, except in the northwestern township,
areas occur. It occupies level delta plain
vated ridges, and owing to its position is g

though some areas in the southwestern township do not have good natural drainage.

The soil is generally of sedimentary origin, being composed of material originally derived from the disintegration of granitic rocks carried down and deposited by the Kern River.

Alkali is quite generally found in soil of this type where not cultivated or irrigated, the maximum amount being usually in the surface foot, with but little in the subsoil.

The principal crops grown are truck, fruit, alfalfa, and raisin grapes, to all of which the type is excellently adapted.

The following table, giving mechanical analyses of typical samples of the soil and subsoil, shows the texture of the Fresno fine sand:

Mechanical analyses of Fresno fine sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10512	¼ N. of cen. sec. 11, T. 30 S., R. 28 E.	Fine sand, 0 to 24 inches..	0.3	5.0	9.8	47.9	28.0	5.5	3.4
10514	1/16 N. of cen. sec. 18, T. 29 S., R. 28 E.	Fine sand, 0 to 24 inches..	1.0	5.2	5.9	48.3	29.7	6.4	3.5
10515	Subsoil of 10514	Fine sand, 24 to 36 inches.	1.0	4.6	5.0	48.6	29.5	7.3	3.3
10513	Subsoil of 10512	Fine sand, 24 to 48 inches.	.7	5.0	9.3	50.3	25.4	5.5	3.4

FRESNO FINE SANDY LOAM.

The Fresno fine sandy loam consists of yellowish or dark-drab micaceous fine sandy loam, quite uniform in texture, and extending to a depth of from 3 to 6 feet. As mapped in the area surveyed, the depth varies irregularly on account of its mode of formation. When not extending to a depth of 6 feet the lower 2 or 3 feet may be sand, fine sand, sandy loam, or rarely, loam. Usually this underlying material is of the same origin as the soil and is in general of much the same character, differing only in texture.

The type is quite generally distributed in the central and southern parts of the area, but very little of it is found in the northern part, though a similar sandy loam material was occasionally encountered there underlying the sandy adobe.

The Fresno fine sandy loam occurs in the level delta plains and in the lower or slightly depressed draws and basins. Generally the drainage is good, though many isolated areas have poor natural drainage, with subsoil water within 4 or 5 feet of the surface.

This type of soil has been formed almost entirely from sediments deposited by the Kern River and originally derived from the disintegration products of granitic rocks in Kern Canyon. Much of the type, where not cultivated or irrigated, contains both white and black alkali, with the maximum amount usually in the surface foot.

The Fresno fine sandy loam is cultivated chiefly to alfalfa, fruit, truck, and raisin grapes and is adapted to any crop suited to the climatic conditions of the area.

The following mechanical analyses show the texture of this type of soil:

Mechanical analyses of Fresno fine sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10517	½ mile W. of cen. sec. 6, T. 30 S., R. 28 E.	Fine sandy loam, 0 to 12 inches.	1.5	6.4	4.5	12.5	29.9	32.0	13.1
10519	SE. cor. sec. 2, T. 30 S., R. 27 E.	Silt loam, 0 to 12 inches	.5	1.2	1.0	5.1	11.8	61.1	19.8
10518	Subsoil of 10517	Fine sandy loam, 12 to 72 inches.	2.2	4.1	3.3	16.1	26.0	39.9	8.3
10520	Subsoil of 10519	Fine sandy loam, 12 to 72 inches.	1.2	3.4	6.3	25.7	28.5	25.6	9.0

PLACENTIA SANDY LOAM.

The Placentia sandy loam consists of from 12 to 18 inches of compact coarse sandy loam, containing considerable fine sand and fine gravel, underlain to a depth of 3 or 4 feet with heavy, coarse, red sandy loam, quite compact and hard, containing considerable clay and approaching sandy adobe in texture. This is underlain to 6 feet with a lighter phase of the same material, but without the adobe property. The type is intermediary between the compact phase of the Fresno sand and the Maricopa sandy adobe.

This type of soil is located in the northern and northeastern parts of the area. The areas in the latter region have a gentle slope from the foothills forming the boundary on the north, while the other areas are practically level. The soil is naturally well drained and usually free from harmful accumulations of alkali, though the subsoil sometimes contains appreciable quantities.

This type is principally colluvial, having been formed chiefly from wash from the foothills lying to the north.

Only small areas of the type are at present under cultivation, and they are planted chiefly to alfalfa. Small orchards and one or two small orange groves have been set out and are doing well. Under irrigation the type is adapted principally to alfalfa and fruit.

The following table gives the results of a mechanical analysis of this soil:

Mechanical analysis of Placentia sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10528	W. cen. sec. 27, T. 29 S., R. 28 E.	Coarse sandy loam, 0 to 12 inches.	10.6	13.2	6.7	19.1	20.6	18.9	10.7

MARICOPA LOAM.

The Maricopa loam consists of from 18 to 24 inches of sticky, pink or reddish very fine loam, underlain to 3 or 3½ feet by loam of similar appearance containing layers of lime carbonate hardpan, with indications of soluble alkaline carbonates. This is underlain to 6 feet by a sticky, whitish-gray fine loam of ashy texture and appearance and of puttylike consistency, usually containing less clay than the upper soil. The small areas of loam mapped in the southwestern township as a rule do not contain hardpan, and the soil is also quite heavily impregnated with organic matter, which is not the case with the larger, typical areas of the type.

The most typical areas are located in the northeastern part of the area, are rather low-lying and level, and are not naturally well drained.

The Maricopa loam is of both alluvial and colluvial origin, having been formed partly from wash from the canyon of Caliente Creek and the foothills forming the northeastern boundary of the area surveyed, and partly from sediments deposited by the Kern River. The small areas of loam in the southwestern township of the area are entirely alluvial in origin, having been formed by deposition of the finer particles carried by the Kern River.

Most of the type contains considerable alkali, both white and black, in soil and subsoil, which condition will be discussed in a succeeding chapter.

Only small local areas of the Maricopa loam have been brought under cultivation, owing chiefly to excess of alkali and to lack of irrigation facilities. The small areas, when reclaimed, give fairly good yields of alfalfa. A few thrifty olive trees are also found on this type. It is not an ideal soil, however, for fruit trees and deep-rooted crops, owing to the quite generally distributed lime hardpan.

Mechanical analyses of Maricopa loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10521	S. cen. sec. 34, T. 29 S., R. 28 E.	Heavy loam, 0 to 12 inches.	0.3	3.0	3.2	10.1	22.6	35.1	25.4
10522	Subsoil of 10521......	Heavy loam, 24 to 48 inches.	4.9	7.4	4.7	10.3	14.7	33.3	24.6

OXNARD SILT LOAM.

The Oxnard silt loam consists of a very fine, smooth, chocolate-brown silt loam of uniform texture and generally 6 feet or more in depth. It contains considerable very fine micaceous material, and the subsoil is sometimes streaked or underlain by micaceous fine sand or fine sandy loam. In a dry condition it is loose and powdery, and may readily be taken for a soil of fine sandy character. When wet, however, it becomes very sticky and exhibits the peculiar smooth properties of the true silt loams.

This soil type occurs only in the extreme southeastern portion of the area, occupying a rather flat and low tract, cut by sloughs and remnants of former stream channels bordering the soils of the valley plain lying east of the Bakersfield area. The surface is level and covered in places with a heavy growth of the alkali-loving bushy samphire, also known locally as "greasewood" (*Allenrolfea occidentalis*). On the eastern portion of the main soil body this shrubby growth gives way to the saltwort (*Dondia* sp.).

The typical loose and open structure of this soil gives it excellent natural drainage, often in marked contrast to adjoining bodies of the Maricopa loam. It may, however, under unwise or lax methods of irrigation become puddled and more dense and heavy. Although drainage is favored by the soil texture and structure the physiographic position of the land is such that artificial drainage is difficult. However, some of the old slough channels extending through this type might be rendered of some value in removing limited quantities of excess seepage or irrigation waters. The formation of a reclamation district, with the right to condemn and acquire lands lying in the natural drainage basin to the south, must necessarily precede drainage on an extensive scale.

The Oxnard silt loam originates from the very fine sediments laid down at some former period by the slack waters of older channels of the Kern River.

With little exception the soil is heavily impregnated with the soluble alkali salts, a large part being sodium chloride or common salt. A heavy crust or loose alkali mulch generally appears upon the soil surface, but the lime carbonate hardpan of the Maricopa loam and injurious quantities of the destructive black alkali or sodium carbonate of adjoining soil types are, so far as observed, entirely lacking. Owing to the presence of white alkali on the surface, to the present limited water supply, and to the lack of artificial drainage, this soil type is entirely uncultivated and must be classed as desert land. With the securing of better drainage, even by occasional open drains, and a more abundant water supply, this land, although heavily charged with alkali salts, should be capable of complete and rapid reclamation. It should become very productive and well adapted to the growing of alfalfa, corn, grains, and other crops.

The following table of mechanical analyses shows the texture of typical samples of this soil:

Mechanical analyses of Oxnard silt loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10526	¼ mile E. of cen. sec. 27, T. 30 S., R. 28 E.	Brown silty loam, 0 to 12 inches.	0.4	0.9	0.6	6.3	21.3	42.6	27.8
10527	Subsoil of 10526	Brown silty loam, 12 to 72 inches.	.5	.8	.8	9.2	18.2	48.0	22.5

MARICOPA SANDY ADOBE.

The Maricopa sandy adobe consists of a few inches to about 1 foot of coarse sand or sandy loam, underlain to 4 or 5 feet by coarse sandy adobe, red in color and very compact, and containing a high percentage of both clay and coarse sand or fine gravel. In many local spots the adobe reaches the surface and extends to 6 feet without much variation in texture or compactness. These small areas can always be recognized by the hard, reddish, shiny, smooth, or slightly cracked surface, bare of vegetation.

The compactness of the subsoil is apparently due partly to the physical arrangement of the coarse, subangular sand and the clay particles, and partly to the cementing action of iron oxides and hydrates. No carbonates were found in the sample examined.

This type of soil occurs entirely in the northern and northeastern parts of the area surveyed. It occupies level, slightly sloping, and slightly depressed areas, and is not typical of any special physiographic features, being found at the highest elevations in the area, in the lowest portions of that section of the area where found, and on the intervening slopes.

In the present condition and state of cultivation and irrigation the areas of this soil are well drained. Excessive irrigation on the higher lying, surrounding areas would undoubtedly cause accumulation of subsoil water in the depressed areas. The danger from this source, however, is not immediate.

The Maricopa sandy adobe is colluvial in origin, and is derived from wash from the range of low hills just north of the soil areas, these hills being largely composed of similar soil. The type is also of later formation, apparently, than the delta soils—the fine sandy loams and fine sands—as shown by the fact that the latter were often found underlying the adobe.

The Maricopa sandy adobe is, generally speaking, free from harmful accumulations of alkali, though the small local spots reaching the surface and extending to a depth of 6 feet or more often contain considerable quantities. As these areas are small and scattered, there will probably be but little trouble from this cause. The alkali found consists entirely of chlorides and sulphates.

Only small areas of this type have yet been cultivated, and these only to alfalfa. This crop does very well with irrigation, the adobe softening under the influence of the water and enabling the roots to penetrate quite readily the heavier subsoil. The sand or sandy loam underlying the adobe also gives a favorable deeper subsoil for this deep-rooted crop. Fruit trees would also undoubtedly do well on this type with irrigation.

The following table gives mechanical analyses of the fine earth portion of this soil:

Mechanical analyses of Maricopa sandy adobe.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10524	¼ S. and ¼ W. of NW. cor. sec. 10, T. 29 S., R. 27 E.	Coarse sandy loam, 0 to 12 inches.	4.5	6.2	4.1	14.9	24.8	28.0	17.4
10525	Subsoil of 10524	Yellow sandy loam, 12 to 72 inches.	8.2	10.4	5.7	14.0	20.8	21.9	19.5

HARDPAN.

Hardpan was found in one or two places in the extreme northern part of the area, in the Fresno sand, but its occurrence is not at all general so far as the area surveyed extends. It is reported that considerable hardpan exists north of the area beneath this type of soil.

In only one soil type—the Maricopa loam—is hardpan found to occur generally, and in this type, with very few exceptions, all borings revealed its presence. The hardpan stratum was usually found at from 18 to 36 inches below the surface, and consisted of insoluble carbonates—calcium and probably magnesium—together with soluble alkaline carbonates. It is usually only 3 to 6 inches in thickness, sometimes less, and is composed of layers separated from each other by thin bands of fine earth or by air spaces. In only one or two borings was it found to be too hard to penetrate with the auger. Generally just above and just below the compactly cemented material thin strata of softer material 1 or 2 inches in thickness were found, being either partially disintegrated hardpan or, more probably, hardpan in process of formation.

As has been observed in other hardpan areas, the cemented material occurs at the place of change from a heavy soil to a lighter subsoil, and usually in the lighter rather than in the heavier soil.

In the Maricopa loam there are usually present considerable quantities of soluble salts, and as the soil occupies a rather low position in relation to the surrounding country it is always moist, the subsoil being usually quite wet. Free water sometimes occurs at a depth of 6 feet. The soluble salts in the surface foot of soil, consisting of sulphates, chlorides, and carbonates, are occasionally carried down below the surface by the heavier rains—a movement made easier and more rapid by the moist condition of the soil. This salt solution, which is quite concentrated, will also carry in solution comparatively large quantities of calcium and magnesium—hydrogen carbonates—these salts having been formed by the aid of carbon dioxide in the soil atmosphere. These bicarbonates being carried down through the heavy surface soil would, on reaching the lighter subsoil, come in contact with larger soil grains, a decreased soil surface, and more free air spaces, and with the decreased partial pressure of carbon dioxide would partially break down, precipitating the normal difficultly soluble carbonates of calcium and magnesium on the soil grains. Continued repetition of this process would eventually form a solid layer of hardpan, which would always by this method form in the lighter soil just below the heavier surface soil.

The subsoil of this type being always very moist or wet, with occasionally free water at a depth of 6 feet, there is undoubtedly an upward movement of salt-carrying water due to capillarity. This solution after having passed through the lighter subsoil would, on reaching the heavier texture soil, come in contact with a much greater soil surface, which would give rise to absorption or deposition on the soil grains. In this case the cementing action would take place in the first layers of the heavier soil just above the lighter subsoil. Both processes of formation are undoubtedly responsible for the hardpan of this area.

As this soil type is cultivated only to a very small extent, no serious trouble has yet been experienced with the hardpan. There is reason to believe, however, that under irrigation, unless practiced to excess, the hardpan conditions would not be greatly ameliorated. Excessive irrigation, on the other hand, would raise the water table to the danger point, and accumulation of alkali might result. Shallow-rooted crops would be better for this soil should it ever become extensively used, and its cultivation should be coupled with artificial underground drainage for permanently good results. Irrigation and underdrainage would gradually but surely remove the hardpan.

WATER SUPPLY FOR IRRIGATION.

The water for irrigation in the Bakersfield area is drawn from two sources, viz, Kern River water and underground water. Of the two sources of supply that of the Kern River is the more important.

This stream, rising as two separate forks in the highest peaks of the Sierra Nevada Range, drains an area of about 2,350 square miles. According to Water Supply and Irrigation Papers, No. 46, United States Geological Survey, the mean annual rainfall of the Kern River drainage basin is about 23 inches. The stream is very rapid, falling about 8,000 feet before entering the valley. The channel is cut through granite, and there is very little loss from seepage or underflow. Below the junction of the South Fork—40 miles above the point where the river emerges from the mountains—such losses begin to occur, while below the canyon, where the stream enters the mesa lands and valley plain, the channel becomes wider, shallower, and of a sandy character, and here the loss rapidly increases until at a point near Bakersfield, owing to the removal of water for irrigation purposes and losses by underflow, the channel generally becomes dry.

Prior to the recent series of dry years and to the extension of irrigation practice upon the delta lands, the waters of the Kern River found their way to the beds of Kern and Buena Vista lakes, and thence northwestward to Lake Tulare, as stated in a preceding chapter. At present, however, aside from losses, the entire flow of the river, except during floods, is utilized for purposes of irrigation. During spring freshets and brief flood periods the excess waters are now conducted into Buena Vista Lake, which has been made available as a reservoir by the construction of a levee along its eastern shore, the storage water being used for the irrigation of lands under the Kern Valley Water Company's canals to the northwest. Evaporation losses here are very great, and owing to this and to the uncertainty of supply this system has met with only partial success.

In flow the Kern River is subject to great seasonal and annual variation. According to reports of the United States Geological Survey above cited, the mean annual discharge at the gaging station near the mouth of the canyon for the period 1895–1899 was 864 second-feet. The low stage occurs during the fall and early winter, at which time a flow of less than 200 second-feet at the gaging station is sometimes reached. The high stage occurs during the spring and early summer, during which a flow exceeding 5,000 second-feet has been recorded.

The location of the main canal systems covering the area may be ascertained by referring to the soil map. Of these the East Side Canal and those covering the delta lands extending southward from the river channel are most important.

As before stated, the construction of irrigating systems has greatly exceeded the available water supply. The large and expensive system of canals and laterals covering the lands of the northern portion of the area is rendered useless during the greater part of the year for want of water. The area watered by the East Side Canal is small and narrow. Lying between this irrigated strip and the land covered by the branches of the Kern Island Canal is a large body of desert and alkali land capable of reclamation under conditions of a more abundant water supply, supplemented by artificial drainage. Vast bodies of unirrigated grazing lands occur in the western and southwestern parts of the area, while upon Kern Island itself, the most extensively cultivated portion of the area, there is in the aggregate a large area of unirrigated land.

No great extension of irrigation within the Bakersfield area can take place under present conditions, since even with the inauguration of greater economy in the use of water and a more careful leveling and preparation of the land which might be practicable, the available water supply is already too limited for the systems so far constructed.

In the case of wells supplying water for irrigation within the limits of the area surveyed, with but few exceptions pumping is necessary. In the valley trough and in the southwestern part of the area artesian or flowing wells are occasionally encountered. The flow of such wells is inconsiderable, however, and is used mainly for the watering of stock on grazing lands, being negligible as a source of water for irrigation.

As an auxiliary supply for tracts unfavorably situated with regard to canal systems, pumping systems are becoming of increasing importance. About 35 electrically driven pumping plants are located within the area. These are operated by power generated in the Kern River Canyon, and are used for the most part in irrigating alfalfa lands of the central and eastern parts of the area, although a certain amount of water is supplied by this means for the irrigation of vineyard and fruit lands on the north side of the river.

The average depth of these wells is about 100 feet, a plant generally comprising four wells sunk in a pit and worked by a single centrifugal pump with direct-connected motor. A reservoir is often profitably used in connection with the system. Some of the larger plants are supplying 2,000 gallons per minute, are operated at a very high percentage of efficiency, and require but little attention. The majority of these plants are owned and operated by the Kern County Land Company in connection with its canal systems, water being supplied to patrons at the rate of 75 cents per acre-foot. In the case of plants operated by smaller individual landowners the cost is somewhat increased.

Upon the mesa lands northeast of Bakersfield an abundant supply of underground water seems to exist, usually at depths of less than 100 feet. With the increasing value of land and water the profitable extension of these systems seems probable. For the smaller plants in use only a portion of the time gasoline engines, using a distillate produced at the local refineries, are said to be more economical than electric motors.

The water obtained from the artesian wells is of very good quality, and that from Kern River is excellent for irrigation purposes, the proportion of soluble alkali salts held in solution being low.

UNDERGROUND AND SEEPAGE WATERS.

It was at first intended to make a map of the Bakersfield area showing the depth to standing water, but upon further investigation such a map was decided to be unnecessary and of doubtful value, owing to the limited water supply and the rather limited areas under cultivation.

Underground water at 6 feet or less was general in only one soil type, viz, the Maricopa loam, and water was not always found so near the surface even in that type. In the remainder of the area a few borings in isolated, low areas found standing water within 3 to 6 feet, but through the area in general it was below 6 feet, and was undoubtedly below 10 feet in the greater part of the area surveyed. A heavy surface coating of alkali, which in many areas almost invariably indicates underground water at 6 feet or less, here seldom high capillarity of the soils of this area, which also explains why in such a hot and dry summer climate more frequent irrigations are not necessary.

An examination of the subsoil water of the area showed that in general it is not badly charged with alkali salts. Wells examined throughout the area, ranging in depth from 10 to 100 feet, were found to contain from 15 to 180 parts of soluble salt per 100,000 parts of water. The higher figure was from one well near Rosedale, and came from the worst subsoil water found. The lower salt contents were from deep wells at pumping stations used for irrigation purposes. The flowing wells of the area were also found to be of good quality. Some sloughs and seepage waters were found to contain from 200 to 300 parts of salts, but very little importance need be attached to the results, as the occurrences are very local.

The principal salt constituent in the subsoil water is hydrogen carbonate, and the quantity present varies from 6 to 60 parts per 100,000. Chlorides varied from 2 to 40 parts, and in one instance 2 parts of normal carbonates were found. In some places heavy precipitates of sulphates were had.

It will be seen that the underground water is not bad, and with the good quality of irrigation water in the area the alkali conditions should be easily controlled.

ALKALI.

The alkali map represents the average percentage of total soluble salts in the soil to a depth of 6 feet, the determinations being made at soil saturation by means of the electrolytic bridge, each foot-section determined separately. As soluble alkaline carbonates, or black alkali, are found in some parts of the area, a black alkali map was also constructed, showing the percentage of this salt in the surface foot. These determinations were made volumetrically in the field on the same samples used in the determination of the total soluble salts. In the black alkali determinations the ratio of dry soil to water used was approximately 10 grams to 250 c. c. These same solutions were used for the quantitative determinations of chlorides and hydrogen carbonates and for qualitative tests for sulphates.

Harmful accumulations of alkali are confined chiefly to the southern half and northwestern corner of the area. Only small local areas of alkali exist in the remainder of the area surveyed.

The general absence of harmful accumulations of alkali in the northern part of the area is due to the lighter soil and greater elevation. The alkali is thus confined chiefly to the heavier soil types, including the Fresno fine sand, the Fresno fine sandy loam, the Maricopa loam, and the Oxnard silt loam. The Fresno sand is practically free from alkali, and but small amounts exist in the Maricopa sandy adobe and the Placentia sandy loam.

By a consideration of the origin of the soils, the vertical distribution of the alkali in the soil, and the climatic conditions of the area, it is apparent that the alkali owes its origin principally to the small amounts of soluble salts in the sediments brought down by the river, which gradually have accumulated at or near the surface by evaporation of subsoil water brought to the surface by capillarity. There are no residual soils in the area surveyed, and all the soils in which large amounts of alkali occur are of alluvial origin. There is no evidence of very deep-seated accumulations of alkali, at least not in the portion of the valley under discussion. Since the maximum salt content was almost invariably found in the surface foot, with very little in the subsoil, it is also evident that the small amounts of soluble salts necessarily found in any soil have concentrated at the surface by the upward movement of the subsoil water carrying the salts in solution.

In making soil investigations in unsettled areas where there were naturally no alkali accumulations in either soil or subsoil, and where only nominal amounts were found by careful examination, it is very common to find in a few years—sometimes only three or four—a very heavy surface accumulation of alkali, sufficient to prohibit the growth of any agricultural plant, such accumulation having been caused entirely by a rise of the water table through irrigation. A small amount of alkali salts—far too little to have any toxic effect on cultivated crops—with uniform vertical distribution in the soil soon gives a heavy surface incrustation under such conditions. This condition is more quickly reached and further aggravated in case the soil has a high capillarity, as is the case with all of the alkali-containing soils in the area surveyed.

The scanty rainfall in the area—about five inches—is not sufficient to wash away any of the surface alkali. The hot summer weather and warm weather during the rest of the season also favor rapid accumulation of surface alkali.

A large number of titrations, covering the whole alkali area, were made in order to ascertain the character of the soluble salts. As will be seen by the black alkali map, very little of this salt was found in the northern half of the area, even where heavy surface accumulations existed. In these places the salts were apparently evenly divided between the chlorides and sulphates. Not having a quantitative field method for sulphates, the relation could be only approximately determined.

In the southern half of the area much alkaline carbonate was found, as well as the "white" alkali. No definite relation existed between the total amount of soluble salt in the surface foot and the amount of soluble alkaline carbonates. In many instances, where as much as from 2 to 7 per cent of the former was found, less than 0.05 per cent of the latter existed. Again, in other places the same amount of salts in the surface foot would yield 0.3 per cent to 1 per cent of alkaline carbonates. High percentages of black alkali, however, were generally associated with much surface salt.

A somewhat curious relation existed between the sulphates and soluble carbonates. While in some instances no black alkali, or only small amounts occurred where much sulphate was found, on the other hand high percentages of alkaline carbonate were more generally found together with large amounts of sulphates. On tabulation of a large number of titrations made and averages computed, it was found that in the cases where heavy or very heavy precipitates of sulphates were obtained the average percentage of soluble alkaline carbonates was seven times as high as where only traces of sulphates or none at all existed.

No definite relation was found between the total amount of soluble salts in the surface foot of soil and the sulphates in the same section. the latter not increasing with the former. On the other hand, the amounts of chlorides were much more constant, and in a general way showed increased amounts, with increasing surface accumulations.

With few exceptions, the bicarbonates were present only in small amounts, and showed no relation in quantity to either the total soluble salts in the surface foot or to any of their constituents, except that, as is nearly always the case, the ratio of bicarbonates to carbonates was greater in the presence of small amounts of the latter than in the presence of large amounts of carbonates. But even then the relation was not very conspicuous.

The vertical distribution of the amounts of soluble salts was very irregular. With very few minor exceptions the maximum salt content occurred in the surface foot, with very rapidly decreasing amounts in the subsoil. Owing to this, it was found that mapping only the average percentage of alkali in the first 6 feet of soil did not give a true conception of the alkali conditions. Therefore a legend of different hatchings was employed on the total alkali map, showing the amount in the surface foot. In many instances quite a heavy surface accumulation of salts would give less than 0.20 per cent for the average of 6 feet. The grade 0.60 to 1 per cent nearly always, and that of 0.40 to 0.60 per cent very often, showed surface accumulations of alkali.

In the Maricopa loam areas, as mentioned in the description of that type, soluble alkaline carbonates were found associated with the lime hardpan in the subsoil. Titrations and other examinations often showed as much black alkali in this subsoil as in the surface foot.

The alkali conditions in the area have in many instances been improved by cultivation and irrigation, but in many other cases conditions have been aggravated.

The method of irrigation practiced in the area—chiefly by contour checks—successfully washes the surface alkali into the subsoil, and this is rendered easier by the fact that the texture of the subsoil is as light or lighter than that of the soil. Some fields in the worst alkali districts in the area—in the southeastern township—have been successfully reclaimed in this way. Borings made in the edges of these alfalfa fields showed less than 0.10 per cent of total salts as an average in the first 6 feet, while a few feet outside the fences the average for the same depth ranged from 1 to 3 per cent.

Owing, however, to the small amount of this work done throughout the area in general, no serious or extensive damage has yet taken place, though in many local places the effect of overirrigation is plainly visible. These local areas could of course be much improved by underdrainage, but owing to the character of the topography it would not be feasible to undertake drainage on a small scale.

The absence of any good natural drainage channels for the area in general makes the question of underdrainage a difficult and expensive problem. The topography of this part of the valley is such that a very general system would have to be installed, much on the same principle as an irrigation system. It would be out of the question to put through such an undertaking at the present time for several reasons. The state of cultivation and character of crops produced would not justify the expense. Considerably less than half the area surveyed is cultivated, some of it not being under any system of irrigation, and much yet unsupplied with irrigation water. Probably less than one-third of the area was irrigated at the time the survey was made, though a few years earlier, when water was more plentiful, a much larger area was irrigated and successfully cultivated.

The scarcity of water for irrigation will in itself make unnecessary any extensive underdrainage in the near future, unless a very much more elaborate system of pumping is introduced, and even then, as this method of irrigation would encourage a very economical use of water, the necessity for underdrainage would be more or less retarded. When the state of cultivation made possible by a larger water supply shall require the use of all the land in the area, underground drainage will be imperative in order to reclaim and keep the land in cultivable condition.

AGRICULTURAL METHODS.

A common method of bringing new land into permanent use is to plant it to corn or grain for from one to three years, thus getting the soil into good physical condition, and, where it exists in injurious quantities, washing the surface alkali into the subsoil. The necessary permanent checks and ditches are thus built, and then the land is usually planted to alfalfa, or sometimes to tree fruits or grapes.

The usual method of irrigation in the area is by contour checks, that method having generally replaced the more wasteful one of "wild" flooding. Considerable initial expense is often incurred in perfecting a good permanent system, in order to increase the duty of water. These check banks are usually from 1 to 3 feet high, and inclose, according to the topography of the field, from one-third or one-half an acre to 2 or 3 acres. In a few instances checks inclosing 10 or 15 acres were seen, but such large areas are not economical, as a rule, and are unsatisfactory, owing to the greater tendency to accumulate subsoil water. The check banks, being permanent, are usually rolled and partially smoothed, so that farm machinery may be drawn across them.

If the fields are large a number of series of checks will be arranged, as a rule, each check opening into some other check of the same series. If the field is small one series will be enough. This arrangement, however, varies with the character of the land, the topography, texture of the soil, and the amount of water available. With a large head of water more checks can be filled without change than with a small flow.

Orchards are usually irrigated by furrows, but occasionally by checks. Grain receives the same treatment in irrigation as alfalfa, the check method being used exclusively.

Alfalfa yields three and sometimes four crops, though usually the field is more valuable for grazing after the third crop is removed than it is for cutting. It is a common practice for cattle and sheep owners to rent fields of all descriptions for grazing in the fall, paying a stipulated price per acre for the privilege.

Alfalfa receives from one to three irrigations a season, more water being necessary in the northern and sandy areas than in the central and southern parts of the area surveyed. In many instances, however, this is not enough, and more frequent applications would be more remunerative. In the southern and central portions of the area, where the subsoil water is nearer the surface, two irrigations are usually sufficient for the entire season.

No attention is paid to rotation of crops when grain is grown, cereal succeeding cereal as long as it is desired to raise those crops. In fact, very little agricultural skill is shown in the area, so far as general farming is concerned, with the possible exception of the irrigation practices. The area is not yet densely enough settled to call for any but the most general farming methods. The only intensive cultivation practiced in the area is carried on by the Chinese on their small tracts of land devoted to truck growing.

AGRICULTURAL CONDITIONS.

The agricultural conditions in the area surveyed differ somewhat from those generally found in agricultural communities. Instead of the area being dotted with convenient-sized farms, each with its comfortable house and outbuildings, well-cultivated land, and carefully kept surroundings, one finds large areas of land owned or controlled by companies or wealthy individuals. According to maps made in 1896, one company alone then owned over 50,000 acres in the area surveyed and much larger tracts adjoining the area. Another company not owning very large tracts in the area surveyed owns probably hundreds of square miles south, west, and north of the area. Hence, instead of a dense farm population one finds here and there a few buildings, or perhaps only one small house for the accommodation of the person or persons looking after the property of another. Scattered here and there over the area are a few well-kept and well-cultivated farms owned by more prosperous farmers, who can devote their time and energy to their own interests.

The holders of wide tracts of land have overseers or managers, who carry on large operations by means of labor hired for the work. In other instances a certain amount of land is rented to tenants for a specified number of years. The labor hired is drawn chiefly from the floating foreign population, consisting largely of Chinese, Japanese, Portuguese, and Italians, the first two races being especially steady and reliable.

The principal crops grown are alfalfa and other forage crops. Alfalfa does well on most of the soil types and is a paying crop, selling at the time of this survey for from $12 to $14 a ton. Barley, hay, and clover also receive some attention, but are distinctly second to alfalfa in importance. Part of the forage crops is fed to sheep and cattle at home, and some is shipped to outside markets. Large numbers of cattle and sheep, with some hogs, are raised in the area and in the valley generally, and during the winter the first two classes of animals are pastured in large herds in the fenced fields or tended by herders in the open virgin areas. During spring and summer the surrounding hills and mountains generally afford a good feeding ground. The winters being very mild, no shelter is necessary for sheep, cattle, or hogs. The range cattle are generally conspicuous for their long horns and vicious character. The better breeds of cattle are not numerous in the area, though an occasional small herd of good dairy cattle was noticed.

Fruit was formerly of some importance, but of late years not many orchards have been set out. This is due to the uncertainty of the spring season. The mild winters bring out the fruit buds early in the spring, before the danger of night frosts is over, and as a consequence the buds are often nipped and the prospective crops destroyed. The woody portion of the fruit trees grows rapidly, as practically all the plant energy can be devoted to this development. In seasons when the fruit escapes frosts the trees are usually not pruned back sufficiently, with the result that they overbear. A number of instances were met where the farmers were cutting out their orchards and planting forage crops instead.

Small grain receives some attention, but chiefly for the purpose of preparing the land for alfalfa or some other forage crop. Corn is grown to some extent for the same purpose.

Raisin grapes are a relatively important product of the area, and the vineyards are usually well kept. This crop is produced chiefly on the Fresno sand.

Six or seven years ago the area was much more extensively cultivated than at present, especially in the northern part, and for many miles north of the northern boundary. In late years the water supply has greatly diminished, and many square miles of alfalfa and orchards that formerly were doing well were, at the time of the survey, entirely dead and the cultivation of the land temporarily abandoned. The spring of 1904 was more hopeful than many preceding seasons in the matter of rainfall. It is quite likely that another cycle of rainy seasons is approaching.

A few small orange groves in the area were doing well, but the best orange district is south of the area surveyed, along the foothills at the southern end of the valley. Figs are raised, but only as an incidental crop, the trees being planted, as a rule, only along the sides and fences of the fields.

Most of the nonalkaline soils are pretty well adapted, under irrigation, to any crop suited to the climate, so that very little attention need be paid to adaptation of soils to crops.

The area would no doubt be much more important agriculturally than it is at present if the land holdings in general were smaller. This would furnish homes for quite a large population and result in more intensive cultivation.

Transportation facilities are excellent, two important railroads, the Southern Pacific and a line of the Santa Fe system, traversing the area and valley, and giving an outlet in all directions for the products grown.

SOIL SURVEY OF THE SAN BERNA
CALIFORNIA.

By J. GARNETT HOLMES, HERBERT W. MA
ALDERT S. ROOT, A. T. SWEET, and W.

LOCATION AND BOUNDARIES OF T

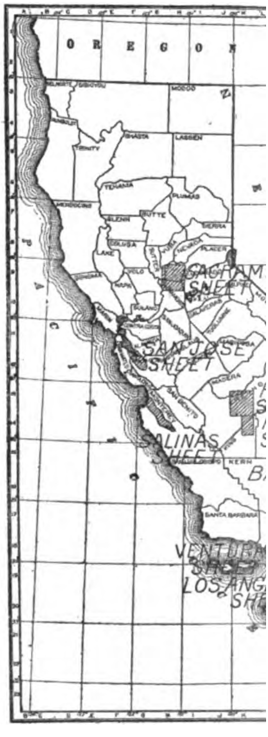

Fig. 45.—Sketch map showing
area, C

Southern California proper is composed c Fernando, San Gabriel, and San Bernardino— formed by the deltas of the rivers which flow through these valleys. Of the three valleys the San Bernardino is the largest and is also farthest from Los Angeles. It is bounded on the north and northeast by the high, precipitous Sierra Madre range of mountains; on the southeast by low, well-weathered hills of granite, which in a few places may be cultivated, and on the south by the Coast Range. To the west is the San Gabriel Valley, the divide between the two valleys being a ridge passing through the city of Pomona, but of such gradual slope as not to b Pomona, at the extreme western end of the val the Coast Range. The principal towns of the valley are San Bernardino, Redlands, Riverside, Corona, Ontario, Chino, and Pomona. Other small towns and settlements in the valley are the centers of important agricultural communities.

Southeast of Riverside, in the southeastern part of the area mapped. and beyond the uncultivated hills, is the Perris or San Jacinto Valley. This valley is much higher than the San Bernandino, and is cut off from it by low, undulating hills. In the San Jacinto Valley are the towns of Perris, Moreno, Lakeview, and Hemet.

HISTORY OF SETTLEMENT AND AGRICULTURAL DEVELOPMENT.

When southern California was first visited by the padres and the mission established at San Gabriel, the whole country was in a wild, uncultivated state. There were occasional settlements of Indians, who made no attempt to cultivate the soil or derive any direct benefits from it. Except for the wild game that roamed at will over the broad prairies of the valleys and foothills and fed upon the native grasses the ranges were unstocked.

For a number of years after the establishment of this mission (1771) the fathers were busy conquering the desert—planting vineyards and fields of grain in the immediate vicinity of the mission in the San Gabriel Valley. To assist in this work, the natives were impressed as laborers, and many of them were taught the rudiments of irrigation in this way. The knowledge thus gained from the example of the fathers gradually spread to the tribes throughout this section, who, in a limited way, soon constructed small ditches along the Santa Ana River and its tributaries to irrigate tracts of land in the bottoms. These ditches were crude in the extreme, but were valuable as demonstrating what might be done.

Gradually others followed the fathers into this fertile region. Large tracts of the valley were granted to individuals by the Mexican authorities. These large tracts were used exclusively for stock raising, and during the latter part of the period of Mexican occupation thousands of cattle roamed over the valley and foothills. In the spring and early summer the native vegetation was green and succulent, and after the rainy season this " feed " cured on the ground and furnished a very nutritive dry feed for the remainder of the year. The owners of these old grants were literally " lords of all they surveyed," as the grants were large, often extending as far as the eye could reach in every direction from the central ranch house, or hacienda. Many " vaqueros " were necessary to look after the cattle, and these men lived with their families in small adobe houses around the large house of the owner, making, in reality, a small village on each of the large ranchos. Often on the larger grants as many as 300 cattle were slaughtered annually to feed these families alone.

In those early days transportation facilities were very poor, the only outlets being to the east by the overland route, and to the west by boat from San Diego or Santa Barbara. Many cattle were slaughtered for their hides alone.

By the close of the Mexican war, in 1848, all the lands of the valley that were considered valuable had been granted to adherents of the Mexican Government, and, with the exception of small areas in the immediate vicinity of streams and a few small vineyards, cattle raising was the sole industry.

The admission of California to the Union, in 1850, and the gold mining activities in the north called especial attention to this State. The gold camps in the northern part of the State offered good and fairly accessible markets for all the fruits and grain that could be grown in the valley, so that the fifties saw these industries somewhat increased. In the sixties sheep were introduced, and, as has been the history of so many other sections, they gradually superseded the cattle, until in the seventies and eighties they were the principal kind of stock raised.

The existence of the large grants in the most desirable portion of the valley, the titles to most of which were confirmed by the United States Government, rather retarded the settlement of the valley, as their Mexican owners looked with disfavor upon the advent of the progressive Americans. The first of these grants to be subdivided was the San Bernardino. A party of Mormons came down from the Salt Lake settlements, where irrigation was such a signal success, and settled on this rancho. Taking water from the Santa Ana River, they engaged in general farming and grape growing, and established the settlement of San Bernardino. They farmed entirely in the moist bottom lands, and, except for the vineyards at Cucamonga, the mesas or uplands were as yet untouched. Oranges had been planted in a small way in the valley, and more extensively to the westward in the San Gabriel Valley and near Los Angeles, demonstrating that this fruit would grow and mature in this climate. The cultivation of the vine, however, was the chief horticultural industry until the establishment of Riverside colony, in 1871. The founding of this settlement, under the name of the Southern California Colony Association, marked a decided departure in the horticultural pursuits of the valley. Prior to this time only the moist bottom lands had been planted, which necessitated the construction of only small and comparatively inexpensive irrigation works. But this company proposed to carry the water up into the mesa lands above the bottoms, which could be done only at great expense for flumes across the canyons, tunnels through hills, etc. Notwithstanding the many physical difficulties and the ridicule of the irrigators on the bottom lands, a year after the establishment of the colony water reached what is now the business part of Riverside. This was accomplished only after the expenditure of $50,000, which was considered at that time an enormous sum to invest in irrigation works. Taking into consideration the purely experimental nature of the enterprise, the financial courage of these early settlers should not be unappreciated. Several thousand acres of land were obtained by the colony and subdivided into 10-acre tracts, upon which it was the purpose to grow fruits. These early settlers, coming from unirrigated general farming districts of the United States, knew next to nothing of the industry in which they were to engage. It is little wonder that the first few years of the settlement's existence were discouraging and fraught with many trials and misgivings. By the end of 1875 only about 1,500 acres had been planted, principally to raisin grapes. A few seedling oranges had been planted, but the grapes at that time brought a high price, and came into fruitage much earlier than the oranges.

In 1875–76 the Riverside Land and Water Company was formed, which took over the old Water and Land Company, bought many acres of new lands, and spent almost immediately $200,000 more in enlarging and extending the canal system. This company exists to the present day, and still furnishes water to the original lands of the settlement. The Washington navel orange, introduced by the Department of Agriculture in 1873, was first planted in this colony, and is often called the Riverside navel. The two trees sent by the Department, buds from which have served to produce thousands of trees, still stand in the city of Riverside. Many of the first groves, however, were wholly of seedling trees, which in the early stages of citrus fruit growing were valuable, but which are now of so inferior a quality as hardly to pay for the care of the groves.

In the early history of the colony grapes and deciduous fruits were extensively grown. In 1889 the income from raisin grapes was more than half and from deciduous fruits about one-eighth that from the citrus fruits.

Although the original Riverside enterprise was considered by many a wildcat scheme, and the dry mesa lands regarded as unfit for fruit growing, the experience of these pioneers demonstrated that such lands were preeminently adapted to the citrus fruits. It was also shown that the higher lands were less liable to frosts, with the result that a new and very large canal was planned and constructed to cover several thousand acres of land above the lands of the Riverside Land and Water Company. This canal is known as the Gage Canal, and first brought water to the land in 1887. The several thousand acres covered by this canal have been almost entirely planted to citrus fruits, and now constitute the principal orange-growing section of the Riverside district. The groves under the ditch are largely navels, under a high state of cultivation and very productive.

On account of seepage, some of the older orange groves have been swamped and made unproductive. The old vineyards, owing to the ravages of the vine disease and the growing value of the land for citrus fruits, have nearly all been superseded by citrus fruits, until at the present day Riverside lands are devoted almost exclusively to this class of fruit, with alfalfa in the lowlands.

Shortly after the establishment of the Riverside settlement the Southern Pacific Railroad was completed through the valley and the towns of Pomona and Colton were founded. Pomona was from the first chiefly a citrus fruit growing district, although a few vines were planted. These old vines are now about all gone, and here, too, the growing of citrus fruits is the main industry. Colton was established as a station from which a motor line reached San Bernardino and Riverside. In late years much fruit has been planted in the vicinity of this town, and it has become an important manufacturing center. Here are located a large Portland cement factory and large flour and feed mills.

The colony of Etiwanda was established in 1880. Grape growing was the principal industry and remains so to the present time, although a few citrus fruits were planted.

Ontario Colony was established in 1883. It includes Upland and San Antonio Heights, and has always been known as the "Model Colony." Citrus fruits were planted quite extensively shortly after its establishment, and the acreage has since been gradually extended. Olives were sometimes planted as a border to the citrus groves, so that at the present time the olive crop is often quite large, and in the aggregate adds considerably to the income of the growers. Deciduous fruits are dried or canned, there being a cannery here.

About 1880 the first settlements were made in the vicinity of what is now Redlands. These settlements grew quite rapidly, and in 1887 the town of Redlands was incorporated. From that time to the present the growth of the town and vicinity has been rapid and of a substantial nature. Redlands is generally spoken of as a town of millionaires. Many wealthy men from other parts of the United States have moved here and built homes in the orange groves. It is one of the most noted tourist towns in the State, and each winter every hotel and boarding house is filled with visitors. The culture of the orange is almost the sole industry. Within the last twenty years the citrus fruit industry has greatly increased all around the highlands of the valley, giving rise to the small towns of Highland, Craftonville, Mentone, and Corona, all of which are mainly dependent on the citrus fruits for their existence.

During this period grain growing has been quite generally extended to all lands of the San Jacinto Valley, and to the lowlands in the valley proper that have not sufficient water for irrigation.

A large sugar factory at Chino was completed in 1891, giving rise to a new industry on the lands of the Chino ranch and vicinity. The product is quite valuable, the beets being grown on moist, slightly alkaline lands, which are best suited to this crop.

In the early eighties quite a boom occurred in the northern part of the San Jacinto or Perris Valley, and many of the lands were sold for fruit growing. The water supply, however, was in litigation, and by the decision of the court the water was given chiefly to the Redlands district, so that at the present time there are only a few small groves in the San Jacinto Valley, the greater part being sown to grain.

In the early nineties grape growing had almost entirely disappeared in the valley. The old vineyard at Cucamonga was about the only one of any size remaining. The others had either been killed by the vine disease or had been uprooted to make way for citrus fruits. In the last few years several thousand acres have been planted to vines along the slope to the south of the Sierra Madre Mountains, in the vicinity of Cucamonga.

All of the principal wagon roads of the district are in excellent condition. Hundreds of miles of these roads have been oiled and brought into good condition. Other roads are sprinkled the year round with water to lay the dust, and the oiling process is being gradually extended to these water-sprinkled stretches. From almost any town in the valley, one traveling to Los Angeles or other important southern California town, need never leave these good roads. When well kept they are smooth, even free from the roughness of the pikes, and as easy on the feet of horses as an ordinary dirt road.

Telephones, rural free delivery, and electric lights have been extended to all the small settlements of the San Bernardino Valley, and excellent schools abound in both town and country.

Further subdivision of the larger groves and the development of more water will greatly increase the number of desirable home tracts in the valley. The horticultural industry is best carried on in small holdings, so that the population of the valley can be greatly increased without congestion.

The climate of the San Bernardino Valley i
of the remainder of southern California, being
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however, a little hotter in summer and less fog
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The mild coast breezes are often felt, but fe
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Strong, hot winds from the interior desert r
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crop.

The climate on the whole is very pleasant, a
of the population of the valley consists of
attracted to it because of this fact. The winte
attractive, and the hotels at this season are fil
health seekers.

The appended table gives the normal mont
perature and precipitation for the Weather B
in the valley. These figures show in a meas
rainfall between the country near the Sierra M
south.

Month.	San Bernardino.		Colton.		Redlands.	
	Temperature.	Precipitation.	Temperature.	Precipitation.	Temperature.	Precipitation.
	°F.	*Inches.*	*°F.*	*Inches.*	*°F.*	*Inches.*
January	51.3	3.24	50.6	1.83	50.8	2.59
February	53.3	2.85	53.2	1.97	52.2	2.67
March	55.1	2.48	57.1	1.91	54.7	2.63
April	59.5	1.24	61.4	.95	61.1	.55
May	64.0	.62	67.5	.52	65.8	.76
June	69.9	.08	73.2	.07	73.8	.10
July	75.0	.04	78.5	.03	78.3	.04
August	74.9	.18	78.9	.02	77.5	.53
September	70.5	.12	73.8	.05	72.1	.37
October	63.1	.59	64.8	.43	65.0	.68
November	57.4	1.45	57.5	.93	58.9	.94
December	52.0	2.89	53.0	1.74	53.2	2.86
Year	62.2	15.78	64.1	10.45	63.6	14.71

PHYSIOGRAPHY AND GEOLOGY.

Viewed from the top of the hills or mountains that surround the valley, it appears as a broad expanse of level land with a few peaks or hills rising abruptly from the generally level floor. Much of the land devoted to citrus fruits, however, has quite an abrupt slope. Along the Sierra Madre Mountains to the north these lands occupy a broad, sloping bench formation, consisting almost wholly of wash from the mountains, which has been carried out upon the older soils of the valley. A few peaks of old hills of the valley still exist in this area. South of the Santa Ana River all the orange lands are either the hills weathered in place to form soil, or wash from these well-weathered hills. These hill lands are quite rough, oranges in the vicinity of Redlands and the upper groves from there around to Corona often being found on quite steep slopes. The older and larger district at Riverside, however, is on comparatively level land—wash from the hills above.

The valley was in times past an area of undulating hills or a foothill region between the Coast Range and the high Sierra Madre. Its present generally level surface is due partly to erosion by the Santa Ana River and the small streams which emerge from the canyons of the Sierra Madre, and partly to the deposit of material from the waters of these streams. The undulating hill lands are the product of weathering in place. Along the upper part of the valley the present surface consists almost wholly of filled-in materials from the Sierra Madre, while farther south are found the heavier, more compact residual materials. The former give rise to the San Gabriel and

Fresno series of soils; the latter produces the Placentia series. From Pomona eastward toward Redlands occasional peaks covered with soils of the Placentia series outcrop in areas of San Gabriel soils, showing the trend of an exceptionally high range of hills that once extended across the valley. For the most part this range has been completely covered by the great volume of material brought down in times of flood from the mountains above. The melting snows and rains from the mountains fill this great gravel bed with water, so that wherever the underlying range of hills is continuous and unbroken for any considerable distance, and approaches the surface, this water is held in check, and the gravels above are water bearing. In some instances, as at Pomona and Claremont, there were formerly springs where the water from above this range of hills was forced to the surface. As soon as wells were put in and the reservoired water lowered these springs dried up, and now all water has to be pumped. Farther east, at Colton, there is a large hill of limestone, the only remains of what must have been at one time a range of sedimentary formation. To the south and southwest of this hill, between Colton and Corona, the hills are of granitic origin, and have weathered into soils of the Placentia series. South and southeast of Pomona the hills are partly of shale and sandstone, which give rise to adobe and other heavy soils and to another series when the wash from these hills is mixed with wash from the Sierra Madre. Here, in the vicinity of Chino, is an artesian belt, where the underflow meets the barriers caused by the hills. Another artesian region occupies the district north of Colton, in the vicinity of San Bernardino. All of these basins are tapped and the water used for irrigation. Wells which originally flowed are nearly all pumped at present.

The Santa Ana River enters the area in the northeastern part, and flows diagonally across the valley, leaving it in the southern part, west of Corona.

South of Corona, in the Coast Range, there is a sandstone and shale formation, principally the latter, the wash from which reaches the valley and forms one of the important soils of the colony.

The Yucaipe Valley, in the eastern end of the sheet, is the small valley of Yucaipe Creek. The formation here is the same as no doubt once existed throughout the San Bernardino Valley proper. The country is nearly all rolling or hilly, according to the stage of decomposition of the hills. The hills are granitic in origin, the granite here having weathered into Placentia soils.

In the center of the valley are some wet lands in which a small amount of peat has been formed. These moist lands, by tunneling and other means of development, are now being used as a source of water for the orange groves near Redlands.

The San Jacinto Valley, situated, as already stated, in the extreme southeastern corner of the area mapped, is a high plateau of granitic origin, consisting of a great body of comparatively level land, dotted over with rough hills of granite. The valley is almost surrounded by granitic mountains and hills, but to the northeast lie the "bad lands," which are composed of incoherent, unsolidified sandstone and shale, which upon weathering give rise to the series of soils found here.

East of Lakeview in this valley is Mystic Lake, now dry.

The San Jacinto River is merely a dry bed, and seldom contains water. Water is found in the valley, however, at depths from which it may be economically pumped.

SOILS.

The soils of the San Bernardino Valley and the surrounding areas mapped divide themselves naturally into two general divisions—those derived from the weathering of granite alone and those derived partly or wholly from the weathering of incoherent, shaly sandstone and shales. The granitic soils are further divided into three series. Those formed from the direct washings of the high, fresh, granite mountains are shown in the very slightly assorted material of the cone deltas or alluvial fans along the Sierra Madre Mountains. The soils of this series are gravelly and all have been formed in a similar manner, the difference in texture being due to a very slight sorting by the small flood streams and a shifting of these streams, causing some areas to be left long without additions of fresh material. The soils thus left have been acted upon by the elements and organic matter has been added from growing shrubs and grasses. In time the sandy loams have been thus formed from the sandy wash material.

Another important series of granitic soils is found along the Santa Ana River and the larger of the other streams. This series represents soils that have been subjected to sorting by these streams. It differs from the one just described in that the particles of soil of each type are of nearly uniform size, but are not of uniform texture to such great depths. They are the usual types found along the valleys of rivers that drain a granitic region.

In the third series of types directly traceable to granitic origin the soils have been formed almost wholly in place by the disintegration and decomposition of the granite. Where the soils have been moved at all by water it has been for only a short distance, and then only after the rock has been thoroughly decomposed. This series is found on and surrounding the old peaks that rise above the floor throughout the valley. It also covers most of the Yucaipe and San Jacinto valleys.

The soils formed wholly or in part from the washings or decomposition in place of the shale and shaly sandstone are found in the southern and southwestern parts of the San Bernardino Valley and in the San Jacinto Valley. Two types found in the valley—Peat and Oxnard sand—are due respectively to the growth of vegetable matter in standing water and to wind action, and can not rightly be placed under any of the above classifications, as they are likely to occur in any favorable locality. In all, eighteen types of soil were recognized and outlined.

The following table gives the actual and proportionate extent of each of these types:

Areas of different soils.

Soil.	Acres.	Per cent.	Soil.	Acres.	Per cent.
Maricopa gravelly sand	157,056	32.5	Maricopa sandy loam	10,304	2.1
Placentia coarse sandy loam	61,760	12.7	Fullerton sandy adobe	9,280	1.9
Placentia sandy loam	87,040	18.1	Oxnard loam	6,912	1.4
Riverwash	27,008	5.6	Salinas gray adobe	6,912	1.4
San Gabriel sandy loam	23,424	4.8	Oxnard sand	4,480	.9
Oxnard fine sandy loam	22,848	4.7	Placentia loam	2,816	.6
Oxnard sandy loam	22,400	4.6	Santiago silt loam	2,112	.4
Fresno sand	15,296	3.2	Peat	704	.1
Fresno fine sandy loam	11,456	2.4	Total	483,008	....
San Joaquin black adobe	11,200	2.3			

RIVERWASH.

Riverwash is composed of the sand, gravel, and bowlders of stream beds. The gravel and bowlders vary greatly in size. In the lower reaches of the stream beds bowlders are absent and the gravel is fine, while near the mountains the bowlders are often several feet in diameter and weigh several tons. Except for the bed of the Santa Ana River, the Riverwash is almost wholly limited to the region skirting the high mountains on the north. Along the steep, sloping talus from Pomona eastward to San Bernardino there are innumerable washes, issuing from the mouths of small canyons of the Sierra Madre. The beds of all these washes are composed wholly of the bowlders and sand classified as Riverwash. There are in all 42 square miles, and the type has practically no agricultural value. No attempt is being made to farm it.

MARICOPA GRAVELLY SAND.

The Maricopa gravelly sand is light to dark gray in color, consisting of particles of decomposing granite ranging in size from very fine sand to gravel 2 or 3 inches in diameter. In all cases practically the same material extends to a greater depth than 6 feet, though the gravel fragments usually increase in size with the depth. The soil is compact when uncultivated, and when newly broken is often quite dark in color, due to the presence of organic matter. After cultivation it becomes a light gray. Many of the small particles of granite in the soil are rotten, and may be broken apart with the hands. The sand is composed of rotten granitic particles deposited upon the plain along with the gravel. It is found principally along the Sierra Madre Mountains, in the northern part of the valley, only small areas being found in the southern part. Its surface has a generally smooth appearance, but the slope is steep, and care must be exercised in irrigating to prevent washing. It is always well drained, as its gravelly and porous nature allows water to sink into it readily, and the steep grade prevents the water from accumulating in quantity in the subsoil.

This type is derived directly from the granite mountains, and is the unsorted waste dumped upon the plain by the flood waters of the small streams. None of it has an accumulation of alkali.

The greater part of the Maricopa gravelly sand is situated in the "frostless belt" mentioned in a previous chapter as extending around the margins of the valley. For this reason, no doubt, rather than because of its special adaptability, citrus fruits are grown wherever water is available. The acreage of land in this frostless zone is far greater than can be irrigated with the water at present available, so that the practice has been to carry the water down to the soil where the percentage of gravel is less and the gravel fragments are smaller. The upper and more gravelly portions are, however, cultivated in places to citrus fruits, which seem to do well.

The older areas of this soil have in some cases stood for some time without receiving additional wash. These older areas have resulted from the shifting of the streams when a cone delta has reached a certain height. In such areas the soil is a little more compact, and is taking on a yellowish cast from the iron oxides. It is on such areas that the colonies of Etiwanda and Cucamonga are situated. In these areas the soil holds moisture better and requires less frequent irrigation, although the character of the materials is not sufficiently different from the soil of the typical areas to justify the establishing of a new type.

Grapes thrive especially well on this soil. During the last few years thousands of acres have been planted in the vicinity of Cucamonga, Vineland, Etiwanda, and Stalder. A few raisin grapes at Etiwanda are irrigated, but the large vineyards of wine and seedless raisin grapes are not irrigated.

Deciduous trees, especially peaches and apricots, have been grown on quite a large acreage without irrigation, and seem to do fairly gravelly, grain is grown, but in dry years it is a of water on account of the leachy nature of the s

Many thousand acres between Ontario and still left to the native vegetation of sagebrush, v pear, and other desert plants.

Grapes, without irrigation, seem to be especi soil, and when water can be obtained for irrigat do well.

The following table gives the mechanical anal ple of fine earth of this soil:

Mechanical analysis of Maricopa gravel

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.
			P. ct.	*P. ct.*
10695	¼ mile E. of Central Ontario.	Gravelly sand, 0 to 24 inches.	11.4	16.1

MARICOPA SANDY LOAM.

The Maricopa sandy loam is a chocolate-br loam 6 feet or more in depth. It is loose, ope cultivation, but in its native, undisturbed state pact. The sand particles are rather coarse an fine material contains a great deal of organic m

This soil is found chiefly in the vicinity of prises about 25 per cent of the soils cultivated has a generally uniform, sloping surface, whi has quite a steep incline. It is found along th mountains whose soils, formed on the mountain into the valley by floods. This type has not t the definite streams as the sandier soils, but ha the floods that have carried before them the lo tains, with humus and other organic matter. open, porous nature and high relative positic drained and free from any accumulation of alk

This soil is devoted almost exclusively to t fruits, to which it is especially well adapted, n situation in the frostless belt, but because of it Grapes would do well without irrigation, and grown on small areas.

Northeast of Ontario, along the base of the Sierra Madre, there is an area of about 2 square miles of the Maricopa sandy loam that is very gravelly and in which the interstitial material is slightly more sticky than in the other areas. It has practically the same crop value, however, although when cultivated the gravel comes to the surface and makes the soil appear more gravelly than it is. These gravel particles range in size from coarse sand to angular fragments 2 or 3 inches in diameter. The origin of this phase of the type is the same as that of the typical soil.

The following table gives the mechanical analysis of a typical sample of the fine earth of the Maricopa sandy loam:

Mechanical analysis of Maricopa sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10394	½ mile S. of Santa Fe Station.	Sandy loam, 0 to 72 inches...	18.6	17.5	9.8	21.2	13.8	17.0	6.9

SAN GABRIEL SANDY LOAM.

The San Gabriel sandy loam is merely a more compact, loamy phase of the Maricopa gravelly sand. It is a light-gray to yellowish-brown, somewhat sandy loam, 6 feet or more in depth, containing in most instances a high percentage of gravel. A few small patches have no appreciable amount of gravel, but their crop value is the same as that of the typical areas.

This soil, with the variations just described, is chiefly found along the great apron of soil creep to the south of the Sierra Madre. It occurs in long strips, which extend into the valley at right angles to the trend of the mountains. Near the mountains these strips are higher than the fresher, newer Maricopa gravelly sand. This is because the streams, after building cone deltas to a certain height, have cut new channels through these small fans to reach the lower lands on each side. The old, higher parts of the cones have thus been left high for a time, and have weathered to sandy loam. Farther from the mountains the areas of sandy loam are lower than the surrounding coarser material, for here the lower reaches of the old cones are being gradually encroached upon by the creeping out of the ones now being built. The surface of this soil type is sufficiently smooth to make irrigation a comparatively simple matter, although the slope is sufficient to necessitate care to prevent washing.

the remainder is almost all planted to grap which are unirrigated. It it well adapted to ci tion, and to grapes without it. Grain does f planted.

The following table gives mechanical analy this type:

Mechanical analyses of San Gabriel s

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5
			P.ct.	*P.*
10678	NW. sec. 32, T. 1 S., R. 3 W.	Gravelly sandy loam, 0 to 36 inches.	7.1	12.
10679	Near cen. sec. 26, T. 1 S., R. 5 W.	Gravelly sandy loam, 0 to 72 inches.	5.1	10.

FRESNO SAND.

The Fresno sand is a light-gray, medium sand, 4 to 20 feet deep, underlain by sand an principally quartz that has been gradually mountains as the less durable constituents of weathered out. It is found chiefly along the the lower edge of the large, gravelly, sandy a mountains. It has a generally level and sm but little preparation for irrigation. Its loos it in all cases well drained, and where the g means of escape it will always remain so.

Like the soils already described, it has it Madre Mountains to the north, and is compos quartz particles which have been sorted over long distances by the Santa Ana River and t valley which come from these mountains.

Almost none of the Fresno sand is planted Some of it along the Santa Ana River is dev here all the truck crops grow abundantly; amount is devoted to pasture or grain farmin the location of the soil in the area with rega supply, however, than to anything in the s unfit for fruit culture. In other parts of s soil produces excellent oranges, walnuts, and deciduous fruits.[a] In this valley the Fresno sand is adapted to truck crops, alfalfa, grain, and deciduous fruits.

The following table gives the mechanical analysis of the fine earth of a typical sample of the Fresno sand:

Mechanical analysis of Fresno sand.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.	P. ct.
10373	1 mile E. of Chino...	Coarse sand, 0 to 48 inches.	10.3	16.6	13.4	34.0	19.7	4.1	1.6

FRESNO FINE SANDY LOAM.

The Fresno fine sandy loam is a light-gray to reddish-brown micaceous fine sandy loam from 4 to 10 or 12 feet deep. It is usually underlain by sand. It is easily cultivated, friable, porous, and takes irrigation water readily. It is found along the Santa Ana River and the lower reaches of the other streams of the valley, and is composed of river-sorted granitic material finer than the Fresno sand. The largest areas occur near San Bernardino in the combined local valleys of the Santa Ana River and Lytle Creek. The surface is comparatively level and smooth, requiring only the removal of native vegetation to prepare it for irrigation.

As a rule its location along the river makes it not so well drained as the other soils of the valley; few areas are suffering from an excess of water.

Like the other soils described, this type has its origin in the granitic mountains to the north, being deposited by the waters of the streams after having been carried some distance, and after the larger particles have been removed from the streams by deposition nearer the mountains.

A few areas of this soil are alkaline, these alkali spots being due to the high water table and neglect in the matter of flooding. Wherever irrigation takes the form of flooding, no damage occurs.

Alfalfa, truck, and grain are grown with good results. This soil, because of its capacity for holding moisture and its ease of cultivation, is especially adapted to trucking.

The table following gives mechanical analyses of typical samples of this soil.

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[a] See Soil Survey around Santa Ana, Cal., Rept. Field Operations Bureau of Soils, 1900, and Soil Survey of San Gabriel Valley, same report, 1901.

Mechanical analyses of Fresno fine sandy loam.

No.	Locality	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10371	1¼ miles NW. of Rincon.	Fine sandy loam, 0 to 72 inches.	0.1	0.8	1.3	24.2	38.2	28.4	6.2
10370	E. cen. sec. 16, T. 2 S., R. 5 W.	Fine sandy loam, 0 to 36 inches.	1.1	4.3	2.8	11.5	27.8	45.5	6.7
10372	W. cen. NE. 160 sec. 4, T. 1 S., R. 4 W.	Fine sandy loam, 0 to 30 inches.	.2	2.1	4.6	22.6	21.3	33.1	16.0

SANTIAGO SILT LOAM.

The Santiago silt loam is a chocolate-brown to black micaceous silt loam from 2 to 4 feet deep. It has a high percentage of organic matter, and in its wild state is covered with a dense growth of native vegetation, consisting of water-loving plants. When moist it is loamy and easily cultivated, but upon drying it bakes and has an appearance somewhat like adobe. The subsoil is nearly always sand of the texture of the Fresno sand, but sometimes is fine sandy loam. Only small bodies of this soil are found in the area. These are located along the Santa Ana and other streams and are level and flat, requiring almost no leveling to prepare them for irrigation. The drainage is usually poor, as the soil has been formed principally in swampy places where water has stood after the subsidence of floods.

Because of its periodical flooding this soil is, as a rule, free from alkali, but as there have been no floods for several years alkali is now accumulating.

Alfalfa, grain, and, in a few instances, berries and deciduous fruits are grown. The type is well adapted to alfalfa and grain growing, as well as to small fruits and berries.

The following table gives mechanical analyses of typical samples of this soil:

Mechanical analyses of Santiago silt loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10402	Near NW. cor. sec. 16, T. 1 S., R. 4 W.	Gray silty loam, 0 to 24 inches.	0.1	0.6	0.4	7.6	14.9	50.0	26.2
10403	Subsoil of 10402	Gray loam, 24 to 72 inches..	1.8	2.2	1.1	13.5	16.1	42.7	22.6

The soils of the Placentia series, while derived, as are the types already described, from the degradation of granite, are of quite a different character. The soils described are nearly all deep, light gray or brown in color, and become lighter and more gravelly as they increase in depth. In the Placentia series the soils have a characteristic reddish color, are comparatively shallow, and are underlain at comparatively slight depths by a compact, claylike, or adobe hardpan.

The Placentia coarse sandy loam is a reddish-brown, coarse, harsh-feeling sandy loam, 18 inches to 4 feet deep, underlain by a rather compact hardpan formation of clay or adobe. The surface when uncultivated becomes very compact and hard, and if dry is difficult to cultivate, breaking up in great lumps. When moist, however, it is easily worked. The sand particles are coarse, often being small particles of granite, approaching the size of peas. This type is found extensively in the San Jacinto Valley and the southern part of the San Bernardino Valley, where it occupies the mesa lands north of Corona.

The surface varies from practically level on the mesas and in the San Jacinto Valley to rolling or hilly and broken in the small ranges, where this soil covers the hills. Since it is rather coarse and high lying drainage is good. It is derived from the degradation of granite in place, or has been transported but short distances.

Grain growing is the principal industry, but in the San Jacinto Valley alfalfa, oranges, and other irrigated crops are grown. The lack of water for irrigation is responsible for the type's being principally given over to grain growing. When irrigated it is an excellent soil for citrus fruits. Grain yields well without irrigation whenever the rainfall is sufficient.

The following table gives mechanical analyses of typical samples of this soil:

Mechanical analyses of Placentia coarse sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P.ct.	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*	*P.ct.*
10388	3 miles N. of Corona.	Brown sandy loam, 0 to 24 inches.	12.8	18.7	9.7	24.6	22.7	5.9	5.3
10390	....	Coarse sandy loam, 0 to 72 inches.	15.1	21.1	10.0	14.0	11.0	19.5	9.3
10391	NE. cor. 9-40 sec. 6, T. 5 S., R. 3 W.	Coarse sandy loam, 0 to 36 inches.	13.1	15.9	8.6	19.6	13.6	19.8	9.4
10389	Subsoil of 10388......	Sandy loam, 24 to 48 inches.	6.4	11.1	5.9	17.1	23.0	15.3	21.1

PLACENTIA SANDY LOAM.

This soil is a micaceous, sticky, slightly plastic, reddish-brown sandy loam, 18 inches to 6 feet or more in depth, and underlain by a hard, compact, claylike hardpan of the texture of Fullerton sandy adobe. When flooded the soil packs and is difficult to till, but when moistened by furrow irrigation it is easily cultivated. This type is found in the southern part of the San Bernardino Valley around Redlands and Riverside, in the Yucaipe Valley, and on the hills and in small areas in the San Bernardino Valley where remnants of old hills protrude through the wash soils from the Sierra Madre Mountains. The surface ranges from practically level around Riverside to very steep and hilly in the ranges of hills in the valley and around its margin. It is all well drained.

The type is derived from the weathering of granite in place, which weathering has consisted chiefly of a chemical decomposition. In some areas the soil has been carried short distances by flood waters. The most important example of this transported soil is at Riverside, where a large level area has been formed from wash from hills to the east and southeast of that place. It is in this area that the soil is deep, sometimes reaching a depth of 6 feet or more, which is unusual for this type. On the lower levels of this large area of deep soil at Riverside a small amount of alkali shows along the ditches and in the orchards, but hardly enough has accumulated to injure the trees.

When unirrigated this soil is sown to grain, of which it yields fair crops. When irrigated it is one of the best citrus fruit soils in the valley. Much of it is in the " frostless belt " and is well drained, so that it is well situated for these fruits. It is upon this soil that the cities of Redlands and Riverside are built, in which are some of the best orange groves in the State.

A gravelly phase of the Placentia sandy loam is found where there is often present quite a high percentage of gravel. Such areas have the same crop value, and occur in the same way as the typical areas. Smiley Heights, at Redlands, is located on this gravel phase, and much of the soil in the vicinity of Redlands belongs to this phase. It is shown on the map by gravel symbols.

The table following gives mechanical analyses of typical samples of the Placentia sandy loam.

Mechanical analyses of Placentia sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10386	¼ mile S. of NE. cor. sec. 34, T. 1 S., R. 3 W.	Gravelly sandy loam, 0 to 36 inches.	15.2	18.8	8.7	15.7	12.3	22.6	6.5
10387	¼ mile E. of N. cen. sec. 33, T. 1 S., R. 3 W.	Sandy loam, 0 to 36 inches.	6.1	10.1	7.5	21.2	18.0	25.8	11.2
10385	N. cen. sec. 32, T. 1 S., R. 3 W.	Gravelly sandy loam, 0 to 36 inches.	4.4	8.8	6.3	18.3	18.5	31.8	11.8

PLACENTIA LOAM.

The Placentia loam is a reddish-brown, sticky, plastic, micaceous loam, 6 feet or more in depth. It is considerably heavier than the sandy loam of the same series, bakes when flooded, and sticks to the fingers and cultivating tools. It contains considerable fine sand, but not enough to make it a fine sandy loam. All of this type is found within the limits of Riverside, surrounded by the area of Placentia sandy loam that has been washed from the hills. The surface is level and smooth. A part is poorly drained and affected by alkali, due to seepage from lands above. It is the assorted finer material derived from the separations of the Placentia sandy loam.

Oranges are now grown on the greater part of the loam, but the trees are chiefly old ones and seedlings, and this area is somewhat affected by frost. Where swamping has injured the trees alfalfa is a paying crop. Citrus fruits on this soil will hang on the trees longer after ripening, and have better keeping qualities than those grown on the more sandy soils.

The following table gives the mechanical analysis of a typical sample of the Placentia loam:

Mechanical analysis of Placentia loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10384	NE. ¼ of SE. cor. sec. 6, T. 3 S., R. 5 W.	Brown heavy loam, 0 to 36 inches.	0.2	0.7	0.6	4.1	21.6	43.9	28.8

FULLERTON SANDY ADOBE.

The Fullerton sandy adobe is a dark-brown, very compact, hard, sticky, plastic sandy adobe, 3 to 6 feet deep, underlain by sandy loam or decomposed granite. It has the peculiar adobe property of breaking up into cubes when dry. It is hard to cultivate, and is usually plowed dry because of its sticky nature when wet. Only a few small areas were found, scattered throughout the Placentia sandy loam in the region north of Corona in the San Bernardino and south of Perris, in the San Jacinto Valley. The surface is rolling or slightly so, and none of the type is irrigated. The drainage is good. The sandy adobe found in this area is derived from the decomposition of granite in place.

All of this soil mapped is devoted to grain growing, for which it is well suited.

The following table gives the mechanical analyses of typical samples of this soil:

Mechanical analyses of Fullerton sandy adobe.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10877	SE. cor. 15-40 sec. 7, T. 4 S., R. 3 W.	Red sandy loam, 0 to 48 inches.	0.5	2.1	3.0	16.4	21.8	36.4	19.7
10874	SW. cor. sec. 30, T. 2 S., R. 6 W.	Brown sandy loam, 0 to 24 inches.	2.8	7.7	6.9	18.7	16.7	21.3	25.7
10876	....	Red clay loam, 0 to 36 inches.	.3	2.1	2.2	9.7	14.0	38.0	33.7
10875	Subsoil of 10874	Brown sandy loam, 24 to 72 inches.	3.7	9.8	10.1	22.7	15.5	23.7	14.2

OXNARD FINE SANDY LOAM.

The Oxnard fine sandy loam is a greenish-gray, rather sticky, micaceous fine sandy loam, 12 to 24 inches in depth, underlain by a rather heavy, sticky, gray sandy loam or loam. It contains, in some instances, small amounts of gravel. It compacts, and if plowed dry breaks up into large clods; when moist it is loamy and easily cultivated. The sand particles are fine, and the soil has a generally soft feel, not harsh, like most soils of the region.

This soil is found wholly in the San Jacinto Valley, in the southeastern part of the area. Its surface is smooth and level and requires but little work in preparing it for irrigation. The greater part is dences of poor drainage in the past.

This soil is derived as a wash from the weathering of an argillaceous incoherent sandstone, which weathers in fantastic shapes. The scoriated and weathered hills are known locally as "Bad lands," and present very rough and precipitous weathered surfaces. A considerable portion of the soil contains alkali, due no doubt to poor drainage when Mystic Lake contains water, as it does after heavy rains.

Wheat, the principal crop, is grown without irrigation, producing well. This is also a good alfalfa and general farming soil, and with irrigation should produce satisfactory yields of many of the common irrigated crops.

The following table gives the mechanical analyses of typical samples of this soil:

Mechanical analyses of Oxnard fine sandy loam.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10699	....	Fine sandy loam, 0 to 36 inches.	3.1	9.5	10.8	35.9	16.3	18.1	6.1
10698	NE. cor. sec. 18, T. 5 S., R. 1 W.	Fine sandy loam, 0 to 24 inches.	.1	2.0	3.6	28.8	22.1	31.6	11.8

OXNARD LOAM.

The Oxnard loam is a gray, sticky, micaceous loam, 6 feet or more in depth, hard when dry, and difficult to cultivate. The soil contains but little sand below the surface 3 or 4 inches, which may be fine sandy loam. It gradually becomes stickier and more plastic as the depth is increased, until the sixth foot is of nearly the same texture as the San Joaquin black adobe.

Like the Oxnard fine sandy loam, this type is found entirely in the San Jacinto Valley. Its surface is level and smooth. The drainage at the time of the survey was good, but the soil shows evidences of poor drainage in the past. It is derived from shale and shaly sandstone, being the finer material deposited on the grade below the fine sandy loam. The greater part contains alkali in varying quantities, and is hence given over almost altogether to pasture. Parts of it, however, are sufficiently free from the injurious salts to grow wheat or alfalfa, in which cases it is a good soil for these crops.

ples of the Oxnard loam:

Mechanical analyses of

No.	Locality.	Description.
10896	NW. cor. sec. 31, T. 4 S., R. 1 W.	Gray loam, 0 to 72 inches
10897	....	Gray loam, 0 to 72 inches

OXNARD SANDY

The Oxnard sandy loam is a dark
ranging in texture from a light fine sa
sticky sandy loam. It is 4 or 5 feet
sandy loam or loam. The heavier ph
plowed, but the major part is not diffi
south and southeast of Chino, principa
surface is level and smooth or only
much work is required to prepare it
drainage is poor, the water coming
necessitating drains to carry off the
partly from wash from the shale and
Chino and partly from the Sierra M
valley. Only the finer wash from th
far out in the valley, however, so that
growths have added much organic m
blacker color than it would have under

Much of this soil contains small an
almost wholly as a surface accumulat
have as much as 0.20 per cent of alkali
having much less than this amount are
the kind of salts and their accumulati
here is in part carbonate of soda, or b
percentages are injurious.

The principal crops are sugar beets a
alkali is not too strong. Some irrigati
but the greater acreage depends on ra
tion. The type is adapted to sugar bee

There is a gravelly phase of the Oxnard sandy loam of sufficient extent and importance to warrant a brief discussion. It is found around the city of Corona and extends south and southeast to the mountains on the south. The surface slopes gently away from the mountains and is cut by occasional small stream beds. The soil is a dark to reddish-brown friable loam to fine sandy loam, containing shale gravel. The gravel fragments, which are all shale, range in size from that of small peas to a diameter of 2 inches. The soil is easily cultivated, well drained, and takes irrigation water readily. It contains no harmful amounts of alkali, although in some of the orchards salts are showing along the small irrigation furrows. This salt, however, comes from the irrigation water used rather than from the soil. Grain and in some instances deciduous fruits are grown without irrigation. Much of this gravelly phase of the Oxnard sandy loam, however, is irrigated and planted to citrus trees, which seem to be doing well.

The following table gives the mechanical analyses of typical samples of the Oxnard sandy loam:

Mechanical analyses of Oxnard sandy loam.

No.	Locality.	Description.	Fine gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10383	Sec. 19, T 2 S., R. 7 W.	Sandy loam, 0 to 2 inches.	0.1	1.0	1.5	12.8	27.2	47.7	10.1
10382	Near cen. sec. 19, T. 2 S., R. 7 W.	Sandy loam, 0 to 36 inches.	.1	.6	1.0	12.7	30.8	44.2	10.6
10380	....	Black sandy loam, 0 to 12 inches.	.4	1.7	2.5	18.9	25.7	39.0	11.0
10404	SW. of Corona	Dark brown loam, 0 to 72 inches.	.7	2.5	2.6	10.4	13.1	45.9	24.4
10381	Subsoil of 10380	Gray heavy loam, 12 to 72 inches.	1.2	7.0	7.9	25.1	21.9	22.0	14.2

SALINAS GRAY ADOBE.

The Salinas gray adobe is a light to dark gray adobe, containing sufficient coarse sand and fine gravel to have nearly the same constituents as sandy loam. The soil is 4 to 6 feet deep, and is underlain by sandy loam or clay loam. Frequently a sort of hardpan occurs at about 4 feet, but in all cases this may be bored through with a field auger. The soil cracks almost in a typical adobe fashion, is sticky, plastic when wet, and hard to cultivate. This soil is found wholly in the San Jacinto Valley, along the San Jacinto River, where

it forms the intermediate soil between the
and the San Joaquin black adobe. The su
slightly sloping, being well adapted to irri
fair, the ground water being at the time of t
below the surface; but in times of heavy fl
rises, as the accumulation of alkali shows
poorly drained.

The soil is a mixture of wash from gran
sandstone, all having been subjected after de
standing water. The greater part is alkal
and is used mainly for pasture. Grain, how
less alkaline portions, and produces well.
would give fair yields. The type is adapte
and other shallow-rooted annuals, sugar bee
to alfalfa.

The following table gives the mechani
samples of the fine earth of this soil:

Mechanical analyses of Salinas g

No.	Locality.	Description.	Gravel, 2 to 1 mm.
			P.ct.
10692	....	Gray clay loam, 0 to 72 inches.	0.7
10696	SE. of Moreno.......	Gray clay, 0 to 72 inches .	.1

SAN JOAQUIN BLACK ADOB

The San Joaquin black adobe is a very bl
like soil which, when dry, breaks up into sm
dry it is very difficult to cultivate, as it is so
adheres to farm tools. It is 4 to 6 feet or m
underlain by shale, shaly sandstone, sandy
area mapped it was found along the imn
Jacinto River and in the western part of
Pomona and south and west of Chino. Al
surface is level, but west and south of Chin
area, representing the capping of the shaly h
age of nearly all the type is good.

The area along the San Jacinto River is de
ing of argillaceous sandstones, being the fine

transported relatively long distances. South and west of Chino the soil comes from shale hills, and most of it has been formed in place. The small streams have pushed some of it out into the valley, where the surface is level and smooth. Varying percentages of alkali occur in the soil along the San Jacinto River and in the area south of Chino, showing that at some past time drainage has been poor.

When farmed at all, grain is the principal crop. Sugar beets are grown in a small way, but the difficulties of tillage have limited the area cultivated to this useful crop. With proper machinery the soil is well adapted to sugar-beet culture. It is an excellent grain soil, as it takes moisture well and retains it sufficiently throughout a season to mature grain.

The following table gives a mechanical analysis of a typical sample of this soil:

Mechanical analysis of San Joaquin black adobe.

No.	Locality.	Description.	Gravel, 2 to 1 mm.	Coarse sand, 1 to 0.5 mm.	Medium sand, 0.5 to 0.25 mm.	Fine sand, 0.25 to 0.1 mm.	Very fine sand, 0.1 to 0.05 mm.	Silt, 0.05 to 0.005 mm.	Clay, 0.005 to 0.0001 mm.
			P. ct.	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*	*P. ct.*
10401	Cen. E. side sec. 5, T. 4 S., R. 3 W.	Black clay, 0 to 72 inches.	0.1	0.3	0.3	4.3	8.8	38.0	48.0

PEAT.

The Peat is made up largely of vegetable matter which has grown and been more or less preserved in standing water. It is very black, friable, easily cultivated, and shows the vegetable matter in a partial state of decomposition. Only two small areas were found—one in the Yucaipe Valley and the other near San Bernardino. The surface is level and smooth. Drainage at present is fair, but the fact that this soil has been formed indicates that it has been poor in times past. The soil may be formed wherever standing water, not too deep to kill aquatic plants, occurs. In these two areas it has been formed by the growing and decaying of tules upon what was an area of Placentia sandy loam in one instance and of silt loam in the other.

This type is an excellent soil for vegetables and all truck crops and is especially adapted to gardening.

OXNARD SAND.

The Oxnard sand is a medium to fine sand, gray to yellowish-gray in color, very loose and incoherent, and 6 feet or more in depth. It is found west of San Bernardino, along the edge of the mesa above Lytle Creek, and in small areas on the great plain east of Chino. Its surface is rolling or undulating, and requires much labor to prepare it for irrigation. The type occurs in ridges or as dunes. It is wind blown, consisting of the fine and medium sand particles blown out of the Maricopa gravelly sand and the San Gabriel sandy loam areas found in the vicinity of these dunes.

A small part of the type is planted to olives, which do not do well. Oranges have been planted on a little of it, and irrigated, but they are also poor. The greater part is uncultivated, but grain sown upon some of the more level lands that have ceased to be moved by the winds does fairly well.

SEEPAGE WATERS AND DRAINAGE.

The constant application of irrigation waters to the porous soils of the valley has had a noticeable effect on the ground water of the lower end of the valley, and locally in the lower levels of the large irrigation communities. All along the lower part of the Santa Ana River much water now comes in from seepage, the bluffs having many small springs at their base. In the older part of Riverside Colony many acres that once had some of the finest orange groves in the valley have in recent years been so affected by seepage that the trees have become unprofitable, and small areas are now so swampy that nothing will grow. Deep drains will so reclaim this swampy land that ordinary crops can be grown. The frequency of frost in these affected areas makes the replanting of oranges after drainage takes place of doubtful expediency.

In the southwestern part of the San Bernardino Valley there is a large area of land, mostly included in the Chino ranch, that has always been moist from seepage. It is only in recent years that irrigation has been practiced at all on these lands, the crops being grown entirely from rainfall and seepage moisture. There are many small seepage sloughs and creeks in this moist region which combine to form Chino Creek, a stream of considerable size that empties into the Santa Ana River near Rincon.

WATER SUPPLY FOR IRRIGATION.

All the water for irrigation in the region mapped, the San Bernardino and San Jacinto valleys, comes directly or indirectly from the precipitation either in the valleys themselves or in the mountains which surround these valleys. Of the precipitation in the valleys themselves very little ever becomes available for irrigation. The greater amount sinks a little way into the soil and is returned to the surface by capillarity, there to be evaporated. The mountains and foothills to the south are low and receive very little more precipitation than the valleys proper, so that the amount of run-off or seepage from this source is practically negligible, leaving the high mountains to the east and north the real source of irrigation waters.

These mountains are high, partially timbered, and for at least a part of the year snow capped. This snow melts rather slowly, and goes to feed the streams which have their source in these high mountains. These streams are augmented and for a part of the year almost wholly fed by springs, the water having been caught and held in the parts having vegetation and a thin veneering of soils, to be given up later from springs in lower levels. That vegetation has a great influence in holding and distributing the water throughout the season has long been recognized. Streams, the immediate watersheds of which have been burned over by forest fires, have a season of high flood during the rainy season and then quickly run dry, while adjacent streams where the vegetation has remained unharmed do not have such disastrous floods, but flow a continuous stream throughout the season. This phenomenon can be observed during any season after forest fires have occurred and has often been observed by the writer. The disastrous effects of these forest fires on the watersheds have led to the establishment of a large forest reserve in the San Bernardino and Sierra Madre mountains, which is carefully patrolled by guards to prevent carelessness on the part of hunters and prospectors. Many trees are being planted. A few years of this careful work should increase the present flow of the streams and tend to distribute the supply more evenly throughout the season.

The principal streams through which this water reaches the valley are the Santa Ana River, Mill Creek, Lytle Creek, and San Antonio Creek. Besides these there are many other small streams which with normal rainfall contain water the year round. Much of the drainage finds its way directly by seepage into the great beds of gravel which underlie the valley, and the larger streams lose a great deal at all times by seepage, so that these gravel beds are saturated with water, giving rise to the artesian basins of the valley and to great bodies of underground water that, while not under pressure, are reservoired in filled ancient depressions, or that move slowly as underground currents.

The hundreds of water companies and individual irrigators in the San Bernardino Valley draw upon either the surface run-off or underground water, or both, for their supply for irrigation and domestic use. Along the northern part of the San Jacinto Valley are a few orange groves, the water for which comes from the Bear Valley reservoir. The remainder of the irrigation in this valley is from wells. A company of Corona irrigators has bought up water-bearing lands in this valley and constructed a ditch to Corona, the water being pumped and carried in the ditch to lands in the vicinity of that place. A few years since a ditch was constructed to Lake Elsinore and water brought in for the same lands, but it was so alkaline that the trees suffered, and in some instances were killed, so that this source of supply had to be abandoned.

Water is brought to the land by all kinds of private and corporate enterprise, ranging from the pumping plant of a single farmer, or of two or three growers combined, to the great Gage Canal, with its costly tunnels, flumes, headworks, and miles of distributing system. To describe these various systems and their methods of distributing or selling water would be an endless task, and would require volumes. Water rights in most of the larger companies are sold at a fixed price per acre, which price is designed to cover cost of construction of canals and headworks, or to go for further water development. An annual rental is paid for water used. In some of the companies no shares exist that are appurtenant to land, so that in dry seasons water may be sold to available lands just as any other commodity is sold, the price varying with supply and demand. The annual cost per acre varies from $4 or $5 on lands having good water rights to as much as $50 in dry years on lands having poor water rights.

All the run-off water and nearly all the artesian and pumped water is of good quality, being almost free from salts. The pumped water of the San Jacinto Valley has quite a little soluble matter, but not enough to be harmful if used in moderation and applied with care.

ALKALI IN SOILS.

The greatest amount of alkali in the area mapped occurs in the San Jacinto Valley. Here, along the San Jacinto River and in Mystic Lake, there are several thousand acres of badly alkaline lands. A few small areas occur along the Santa Ana River. Two districts in Riverside colony have alkali in sufficient quantities to kill citrus fruits. On the Chino ranch much land is affected, but only a few small areas have as much as 0.20 per cent total salts.

In the San Jacinto Valley the alkali comes principally from the salts in the shale and shaly sandstone from which the soils are derived. A part, however, may come from the breaking down and decomposition of the granite of the region. The other areas in the San Bernardino Valley are caused by the evaporation from the surface of the soil of water which contains a small amount of soluble matter. In time sufficient salts are in this way accumulated to injure the land.

In the San Jacinto Valley the alkali often extends to a depth of 6 feet or more, with quite high percentages. Here the soils are heavy and more compact, so that the alkali moves with less freedom and is not all brought to the surface.

Along the Santa Ana River, however, and in the district southeast of Chino the alkali exists almost wholly as a surface accumulation. Below the second foot there is rarely enough to injure any crops.

AGRICULTURAL METHODS AND CONDITIONS.

As in nearly all other parts of southern California, the products of the San Bernardino Valley are widely diversified. The crops and their methods of production range from the most intensive cultivation of a very valuable and high-priced crop—the citrus fruits—to the most extensive farming of a low-grade crop, as exampled in the thousands of acres of dry-farmed grain. Between these extremes are many crops, more or less valuable, and cultivated with varying intensity.

The following table gives in brief form and order of importance the chief soil products of the valley:

- **Horticultural products.**
  - **Citrus fruits.**
    - **Oranges.**
    - **Lemons.**
    - **Pomelos (grape fruit).**
    - **Tangerines.**
    - **Limes.**
    - **Citrons.**
  - **Olives.**
  - **Deciduous fruits.**
    - **Peaches.**
    - **Apricots.**
    - **Pears.**
    - **Apples.**
- **Horticultural products—Continued.**
  - **Deciduous fruits—Continued.**
    - **Prunes.**
    - **Plums.**
  - **Grapes.**
    - **Wine.**
    - **Raisin.**
  - **Small fruits.**
- **Agricultural products:**
  - **Grain.**
    - **Wheat.**
    - **Barley.**
  - **Alfalfa.**
  - **Sugar beets.**

The methods of cultivation and irrigation, size of farms, general prosperity of the farming classes, etc., for each one of these crops differs so greatly that these subjects are discussed for each product rather than for the valley in general.

In a general way the valley has been divided by nature into what are known locally as the uplands and the lowlands, and the farmers have found in this division conditions peculiar to their several needs. On the uplands, where water is available for irrigation, horticulture is almost exclusively the industry. The strictly agricultural crops are grown on the lowlands, or unirrigated grain crops upon such of the highlands as have a suitable soil, but where no irrigation water is available for the more valuable fruit crops.

chiefly dependent upon its horticultural
these are the citrus fruits. The young
eties of this fruit are grown in nurserie
years old, and then transplanted to the
in rows from 20 to 30 feet apart. These
tion, and the most important feature of
ment of abundant water for that purpo
irrigation is used almost exclusively, and
prior to the third year, truck crops are
the rows until that time. If no such c
between the trees is cultivated after ea
weeds and preserve the soil mulch. La
oped water, so that the supply of the la
and made to cover as large an area as pos

On the uniformly sloping Maricopa gr
loam, San Gabriel sandy loam, and the m
Placentia soils irrigation is simple and
hilly types, such as are found near Red
around Riverside, irrigation, even in its
engineering problem, and the greatest
washing. A considerable part of this
row of trees being set on each terrace. C
gation is practiced. At the present tim
abandoned, and now, in new orchards, th
around the hillsides at such a grade as
groves are irrigated by hose, a small ba
tree, but this is done only in a very limit

As soon as the trees come into bearing
problems is that of applying proper ferti
soils and general treatment accorded diffe
difficult the general application of prin
careful growers throughout the valley.
ous growers advocate stable manure as
with dressings of a complete fertilizer.
will not use stable manure at all. Sti
tilizer, depending upon intensive cultiv
crops and the natural breaking down o
Redlands, and in a limited way througho
as a winter cover crop. This crop sho
nitrogen for the citrus fruits, and as this
constituent of commercial fertilizers, th
thereby greatly lessened. Fully 50 pe
for fertilizers could be saved by the gr

nitrogen, and raw material of the best quality bought and mixed at home. This preparation of fertilizers might well be undertaken by the local marketing associations.

Generally speaking, the citrus fruit growers are a prosperous class. However, a large number of those engaged in this business are not directly dependent upon the one industry for a livelihood. Many are wealthy people, attracted to southern California by the climate, who engage in fruit growing as a pastime or at most as a side issue. The many influences that may make any one crop barely pay for production and marketing make it a rather precarious investment for the man of small means, but for the man who can afford to lose an occasional crop, the phenomenal returns of good years make the average return for intelligent handling net a good interest on the investment. One of the largest growers in the valley assured the writer in January, 1904, that from his bearing groves, some of which were purchased at a cost of $1,800 an acre, he has netted so far 20 per cent on the investment.

Nearly all the citrus groves are owned by people who make their homes, at least for a part of the year, in these groves. Some are owned by companies located in towns of the valley, but these are gradually being sold for residence purposes.

The unit of size of groves is 10 acres—many own one, two, or more such plats—but the ordinary grove contains 10 acres, the common price of which, for good bearing trees, is $1,000 an acre.

The upland sandy loam types of soil in this valley are best suited to the growing of citrus fruits. These soils are friable, easily cultivated, take water easily, and are fairly retentive of moisture, so that they furnish an easily penetrable medium for the roots of the trees and insure a quick distribution of fertilizers. These trees are shallow-rooted, so that the heavy subsoil of the Placentia types is not a serious drawback. Some groves are planted on the sand types, but as these sandier soils require more water, and water is scarce and land plentiful, the acreage on such types is small.

At one time in the history of the valley olives were planted quite extensively in groves of small size. It was planned not to irrigate these, but experience demonstrated that without irrigation they would not bear. Most of the groves have since been grubbed out, but a few small ones now receive irrigation and bear fairly well. The best bearing trees of the valley are those planted as a border around well-irrigated orange or lemon groves, thereby receiving regular irrigation. While there are few of these trees in one place, in the aggregate the number is quite large.

Most of the fruit is pickled and sold in the markets of the valley. A little oil is made, but the supply of fruit is too limited in the various localities to warrant the construction of expensive works for olive-oil making.

The deciduous fruits, while of minor importance in horticultural pursuits, are grown in a limited way throughout the entire valley. A few of these orchards are not irrigated, but depend upon the rainfall for their moisture. Where irrigated the furrow method is practiced, as in the citrus groves.

Quite a number of peach orchards are planted upon the Maricopa gravelly sand, along the slope at the base of the Sierra Madre Mountains, where they receive no irrigation. These orchards are not so well kept or so valuable as the citrus groves. Since the water is more valuable for the citrus fruits, the deciduous fruit industry can hardly be said to be a paying one. The orchards are mostly owned by their occupants, the trees having been set out before citrus fruit growing reached its present state of development. Very few deciduous orchards are now being set. The orchards that now exist are usually 5, 10, or 20 acres in extent.

The major part of the deciduous fruit grown in the valley finds a sale in the markets of southern California or at the canneries in the valley, a small amount only being dried and marketed in the eastern cities.

The grapes of the valley are planted almost exclusively on the Maricopa gravelly sand, in the great alluvial fan along the base of the Sierra Madre. There are in all about 10,000 acres, divided among six communities, or settlements, as follows:

	Acres.
Cucamonga	3,000
South Cucamonga	3,000
Stalder	2,000
Etiwanda	1,000
Grapeland	300
North of Lytle Creek	700
Total	10,000

These grapes are chiefly wine grapes or seedless raisin grapes. The Sultana raisin grape is said not to do well here, while the Muscat requires irrigation. The vines are set out in the usual way from cuttings rooted in the nursery, or a long cutting is planted where the vine is to stand. They are set in checks 10 or 12 feet apart, and the space between kept constantly cultivated. Only about 600 or 700 acres of the grapes are irrigated, the remainder depending wholly upon the rainfall for their moisture. These irrigated grapes are seen at Etiwanda, and are principally Muscats, which are dried for raisins. Pruning the vines is an important part of grape culture, and has reached a high state of art. The wine grapevines are pruned back each year to a stump 18 to 30 inches in height. On this stump are left three to five canes, with from three to five buds on each cane, from which eyes or buds come the fruit-bearing vines. The seedless grapes are likewise pruned back to a stump, but for these varieties the stump is low, being only from 12 to 18 inches high. On this three or four canes are left, about 3 or 4 feet long. These long canes are brought together and tied near the ends, making a sort of oblong-shaped frame of the canes themselves. The buds on these long canes produce new canes, upon which the fruit grows. New canes spring out from the stump, another set of which is chosen for the ensuing year, while the old ones are cut away. The Muscats are pruned to stumps close to the ground, from 12 to 18 inches high, and short canes left, as with the wine grapes.

When the grapes are pruned, there is obtained a large amount of wood, which may be rooted for new plants, or if not so needed must be disposed of. Formerly this was carted from the fields at considerable expense. The greater part of this is now burned in a portable sheet-iron furnace, which is drawn through the field by means of a horse attached to the end of a long chain. This greatly lessens the cost of disposition of the pruned canes.

The vineyards are kept in a constant state of cultivation to preserve moisture and keep down weeds. Considerable damage results from strong winds, which sweep down through Cajon Pass and shift the exposed sandy soil about, sometimes undermining and blowing away all the soil from the vines in a limited area and piling this sand up in other places, to the detriment of other vines. Windbreaks will greatly lessen this damage, and some are already being planted. Damage from this source, while noticeable, is not such as to interfere materially with the industry.

Very little commercial fertilizer has been used on the vineyards, but some barnyard manure is used to good advantage. Peas sown between the rows in the winter months might grow almost to maturity, and would, if plowed in, give more consistency to the soil as well as afford a protecting cover crop during the windiest season. Fertilizing by this means would also be a valuable argument in favor of the practice.

The greater proportion of the vineyards has not yet come into bearing, but an old vineyard at Cucamonga has been bearing for years, and the returns are very satisfactory. Nearly all of these vineyards are owned by large companies, with headquarters in Los Angeles. At Etiwanda the vineyards are small, containing from 20 to 80 acres, and are owned by men who live upon them. All the grapes so far grown are of good quality. The seedless and Muscat grapes are used to a limited extent in southern California as table grapes, the remainder being dried for raisins and sold in the regular markets. The wine grapes and the second crop of raisin grapes which sometimes occurs are sold to the wineries of the valley.

Throughout the valley are small patches of strawberries, blackberries, raspberries, and loganberries. These are grown only in a small way, and are consumed by the local markets.

This completes the enumeration of the important horticultural products of the area, and leads to the consideration of the purely agricultural industries.

Grain is the chief agricultural product and is grown throughout the valley wherever the soil is of sufficient consistency to hold moisture near enough to the surface to grow this shallow-rooted crop, and where irrigation water is not obtainable for the more valuable crops. Since rainfall alone is depended upon for moisture for this crop, and droughts sometimes occur which are likely to cause partial or complete failure of this crop, it is the most hazardous of all the industries of the valley. The central lowland part of the valley proper and the San Jacinto Valley in the southeastern part of the area are largely devoted to this crop.

There is no attempt at rotation or summer fallowing to " rest " the ground, as is often the case in other grain-growing sections, but the occasional droughts in a measure take the place of summer fallowing. Where the rainfall is ample large crops are grown, even when the soil is poorly prepared. Hence the usual method is to plow the land to a depth of only 2 or 3 inches with large gang plows, the grain being sown broadcast and plowed under. After one harrowing the fields are left till harvest time. Owing to the hazardous nature of this industry and frequent total loss from drought, the grain farmers are not, as a class, so prosperous as those who can control moisture conditions by irrigation. The grain farms are principally owned in large tracts by nonresidents. These ranches are in some cases the undivided parts of the large grants of the Mexican occupation.

Wheat is the principal grain crop. Much of it is cut for grain and ground at the mills of southern California. In years of excessive yields, however, a great deal of wheat is shipped to the far eastern markets. When the season has insufficient rainfall to mature the wheat for grain, it is cut for hay, which is used in southern California.

Barley is the only other grain grown in any quantity. Much of it is cut for hay, this being the favorite hay for work animals in this region. The fruit-growing districts of the valley afford a ready home market for this hay. That part of the barley not cut for hay is thrashed, and the grain fed chiefly to work stock or fattening animals.

On quite a little of the lower part of the valley, where the climate is not suitable for the semitropical citrus fruits, and where water may be obtained for irrigation, alfalfa is grown in abundance. The principal fields are in the San Jacinto Valley, along the bottom lands of the Santa Ana River, on the seepage-affected lands in Riverside, and on the Chino ranch. Alfalfa is a very valuable crop on these lands, as the water is less expensive than on the higher areas. The fields are laid off in lands, and flooded in much the same way as in the large alfalfa-growing districts of the West. Those engaged in this industry are very prosperous, and nearly all own and live upon the farms they manage. The farms range in size from 10 to 320 acres, and are all in a high state of cultivation. This crop does best upon the lowland sandy loam types, but some farms, when carefully managed, do well upon the heavier loams. Pasturing is done in a small way, but most of the crop is cut, made into hay, and fed in the valley—the greater part to dairy cows—though in seasons of light rainfall, when the grain hay crop is short, much of the alfalfa is fed to work animals. Five to eight crops per year are cut, which average about a ton per acre for each crop. Sold in the markets, this brings, when baled, from $7 to $15 a ton, according to the amount of grain hay on the market.

Sugar beets are grown chiefly on the Chino ranch, in the southwestern part of the San Bernardino Valley. They are also grown by a few small farmers in this vicinity and in the San Jacinto Valley. They are grown principally without irrigation, but lately irrigation of this crop has been introduced. When irrigated the water is applied by the furrow method between the rows. The same methods of planting, thinning, and harvesting obtain here as in other parts of California.[a] The beets are sold at the factory at Chino—one of the factories of the American Beet Sugar Company.

Besides the above-named products of the soil quite a number of crops are grown in a limited way for home consumption. In the vicinity of each town of any size there are gardens, usually tilled by Chinamen, in which are grown vegetables for the towns, as well as for the citrus fruit growers and other farmers, as a garden on a fruit, grain, or alfalfa ranch is the exception. Gardening for the entire valley is carried on in this way in local areas along the river or on other moist areas which are suited to the growth of vegetables.

Bee keeping, especially near the mountains and foothills, is a paying industry, and the honey here produced is of a very fine quality. A part of this is consumed in the local markets, but as all southern California produces honey much is shipped to eastern markets.

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[a] See reports on soil surveys around Imperial and in the Salinas Valley, Field Operations of the Bureau of Soils, 1901.

There are now in the valley three great railroad systems, with branches to every town or settlement of any size. The Southern Pacific traverses the valley in a nearly east and west direction, passing through the towns of Pomona, Ontario, South Cucamonga, and Redlands Junction. Branch lines also extend to Chino and Declezville. A motor line operated by this company also reaches the towns of Redlands, San Bernardino, Highland, and Riverside, touching the main line at Redlands Junction and Chino.

The Santa Fe system, with its included Southern California Railroad, parallels the Southern Pacific across the main part of the valley, passing through North Pomona, Claremont, North Ontario, North Cucamonga, Rialto, San Bernardino, Highland, Mentone, Craftonville, Redlands, Riverside, and Corona. A branch also extends to the San Jacinto Valley, reaching the towns of Alessandro, Perris, and Lakeview.

The Salt Lake and San Pedro Railroad is now building, having reached Riverside from the Pacific coast terminus. It passes through Pomona and Ontario, and is to be extended to other towns of the valley. These railroads insure rapid and easy transportation to all parts of the valley.

The Santa Fe and Southern Pacific roads now have through connections to eastern markets, and all roads have a Pacific coast terminus within 35 to 60 miles, where the nonperishable products may be transferred to ships for export, or for cheap shipment to available points in the United States.

APPENDIX.

(The Field Operations of the Bureau of Soils can be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., if the proper sum is sent in money order or currency.)

Field Operations of the Division of Soils in 1899. **By Milton Whitney, with accompanying papers by Thomas H. Means, Frank D. Gardner, Clarence W. Dorsey, Frank K. Cameron, and Lyman J. Briggs.** Pp. 198, pls. 29, figs. 19, lithograph maps 11. 1900. Price, 95 cents.

CONTENTS.[a]

General Review of the Work. By the Chief of the Division. (Exhausted.)

A Soil Survey in the Pecos Valley, New Mexico (100 square miles). By Thomas H. Means and Frank D. Gardner. (Exhausted.)

A Soil Survey in Salt Lake Valley, Utah (250 square miles). By Frank D. Gardner and John Stewart. (Exhausted.)

A Reconnoissance in Sanpete, Cache, and Utah Counties, Utah. By Thomas H. Means. (Exhausted.)

A Reconnoissance in the Cache a la Poudre Valley, Colorado. By Thomas H. Means. (Exhausted.)

A Soil Survey in the Connecticut Valley, Connecticut and Masachusetts (400 square miles). By Clarence W. Dorsey and Jay A. Bonsteel (Exhausted.)

Application of the Theory of Solution to the Study of Soils. By Frank K. Cameron. (Exhausted.)

Some Necessary Modifications in Methods of Mechanical Analysis as Applied to Alkali Soils. By Lyman J. Briggs. (Exhausted.)

Salts as Influencing the Rate of Evaporation of Water from Soils. By Lyman J. Briggs. (Exhausted.)

Field Operations of the Division of Soils in 1900. By Milton Whitney, Chief of the Division, with accompanying papers by Thomas H. Means, Frank D. Gardner, Clarence W. Dorsey, Jay A. Bonsteel, William G. Smith, J. Garnett Holmes, Frank K. Cameron, Lyman J. Briggs, and Marcus L. Floyd. Pp. 474, pls. 51, figs. 47, lithograph maps 24. 1901. Price, $1.80.

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[a] The several papers enumerated in this appendix, with the accompanying maps, have been issued as separates and can be had upon application to the Bureau of Soils, except where exhausted, the editions of the papers so marked being exhausted. Beginning with 1903, the reports on individual areas are issued as advance sheets, and may be obtained upon application to the Senators for the State, the Representative within whose district the survey lies, or to the Bureau of Soils, United States Department of Agriculture.

CONTENTS.

General Review of the Work. By the Chief of the Division. (Exhausted.)

A Soil Survey around Lancaster, Pennsylvania (270 square miles). By Clarence W. Dorsey.

Soil Survey of Montgomery County, Ohio (480 square miles). By Clarence W. Dorsey and George N. Coffey.

Soil Survey of Cecil County, Maryland (375 square miles). By Clarence W. Dorsey and Jay A. Bonsteel.

Soil Survey of St. Mary County, Maryland (360 square miles). By Jay A. Bonsteel.

Soil Survey of Calvert County, Maryland (218 square miles). By Jay A. Bonsteel and R. T. Avon Burke.

Soil Survey of Kent County, Maryland (315 square miles). By Jay A. Bonsteel.

Soil Survey from Raleigh to Newbern, North Carolina (1,000 square miles). By William G. Smith. (Exhausted.)

Soil Survey in Weber County, Utah (307 square miles). By Frank D. Gardner and Charles A. Jensen. (Exhausted.)

Soil Survey in the Sevier Valley, Utah (220 square miles). By Frank D. Gardner and Charles A. Jensen. (Exhausted.)

Soil Survey in Salt River Valley, Arizona (370 square miles). By Thomas H. Means. (Exhausted.)

Soil Survey around Fresno, California (625 square miles). By Thomas H. Means and J. Garnett Holmes. (Exhausted.)

Soil Survey around Santa Ana, California (300 square miles). By J. Garnett Holmes. (Exhausted.)

Investigations on the Physical Properties of Soils. By Lyman J. Briggs. (Exhausted.)

Application of the Theory of Solution to the Study of Soils. By Frank K. Cameron. (Exhausted.)

Results of Tobacco Experiments Conducted in Various Parts of the United States. By Marcus L. Floyd. (Exhausted.)

Field Operations of the Bureau of Soils, 1901. By Milton Whitney, Chief of Bureau, with accompanying papers by assistants in charge of field parties. Pp. 647, pls. 96, figs. 25, lithograph maps 31. 1902. Price, $2.25.

CONTENTS.

General Review of the Work. By the Chief of the Bureau. (Exhausted.)

Soil Survey in the Westfield Area, New York (260 square miles). By R. T. Avon Burke and Herbert W. Marean.

Soil Survey of Allegan County, Michigan (828 square miles). By Elmer O. Fippin and Thomas D. Rice.

Soil Survey of the Salem Area, New Jersey (493 square miles). By Jay A. Bonsteel and F. W. Taylor.

Soil Survey of the Lebanon Area, Pennsylvania (669 square miles). By William G. Smith and Frank Bennett, jr.

Soil Survey of Prince George County, Maryland (480 square miles). By Jay A. Bonsteel and party.

Soil Survey of Harford County, Maryland (418 square miles). By William G. Smith and J. O. Martin.

Soil Survey of the Bedford Area, Virginia (632 square miles). By Charles N. Mooney, F. O. Martin, and Thomas A. Caine.

Soil Survey of the Prince Edward Area, Virginia (430 square miles). By Charles N. Mooney and Thomas A. Caine.

Soil Survey of the Statesville Area, North Carolina (784 square miles). By Clarence W. Dorsey and party.

Soil Survey of Alamance County, North Carolina (365 square miles). By George N. Coffey and W. Edward Hearn.

Soil Survey of the Cary Area, North Carolina (63 square miles). By George N. Coffey and W. Edward Hearn. (Exhausted.)

Soil Survey of Cobb County, Georgia (346 square miles). By R. T. Avon Burke and Herbert W. Marean.

Soil Survey of the Covington Area, Georgia (225 square miles). By Herbert W. Marean.

Soil Survey of Montgomery County, Tennessee (547 square miles). By J. E. Lapham and M. F. Miller.

Soil Survey of the Yazoo Area, Mississippi (656 square miles). By Jay A. Bonsteel and party.

Soil Survey of the Yakima Area, Washington (309 square miles). By Charles A. Jensen and B. A. Olshausen.

Soil Survey of the Boise Area, Idaho (399 square miles). By Charles A. Jensen and B. A. Olshausen.

Soil Survey of the Hanford Area, California (216 square miles). By Macy H. Lapham and W. H. Heileman.

Soil Survey of the Lower Salinas Valley, California (344 square miles). By Macy H. Lapham.

Soil Survey of the Ventura Area, California (240 square miles). By J. Garnett Holmes and Louis Mesmer.

Soil Survey of the San Gabriel Area, California (259 square miles). By J. Garnett Holmes and Louis Mesmer.

Soil Survey of the Imperial Area, California (169 square miles). By Thomas H. Means and J. Garnett Holmes.

Soil Survey of the Willis Area, Montgomery County, Texas (215 square miles). By J. O. Martin.

Soil Survey of the Lake Charles Area, Louisiana (202 square miles). By W. H. Heileman and Louis Mesmer.

Field Operations of the Bureau of Soils, 1902. By Milton Whitney, Chief of Bureau, with accompanying papers by assistants in charge of field parties. Pp. 842, pls. 60, figs. 25, lithographic maps 44. 1903. Price, $3.80.

CONTENTS.

General Review of the Work. By the Chief of the Bureau. (Exhausted.)

Soil Survey of the Bigflats Area, New York (223 square miles). By Louis Mesmer and W. Edward Hearn.

Soil Survey of the Lyons Area, New York (515 square miles). By W. Edward Hearn.

Soil Survey of the Trenton Area, New Jersey (810 square miles). By R. T. Avon Burke and H. J. Wilder.

Soil Survey of the Albemarle Area, Virginia (1,410 square miles). By Charles N. Mooney and F. E. Bonsteel.

Soil Survey of the Hickory Area, North Carolina (988 square miles). By Thomas A. Caine.

miles). By Thomas A. Caine and A. W. Mangum.

Soil Survey of the Abbeville Area, South Carolina (1,006 square miles). By F. W. Taylor and Thomas D. Rice.

Soil Survey of the Darlington Area, South Carolina (600 square miles). By Thomas D. Rice and F. W. Taylor.

Soil Survey of Perry County, Ala. (762 square miles). By R. T. Avon Burke and party.

Soil Survey of the Smedes Area, Mississippi (463 square miles). By William G. Smith and William T. Carter, jr.

Soil Survey of the Brazoria Area, Texas (845 square miles). By Frank Bennett, jr., and Grove B. Jones.

Soil Survey of the Vernon Area, Texas (277 square miles). By J. E. Lapham and party.

Soil Survey of the Toledo Area, Ohio (403 square miles). By William G. Smith.

Soil Survey of the Columbus Area, Ohio (472 square miles). By William G. Smith.

Soil Survey of Union County, Kentucky (361 square miles). By Herbert W. Marean.

Soil Survey of Posey County, Indiana (387 square miles). By Herbert W. Marean.

Soil Survey of Tazewell County, Illinois (645 square miles). By Jay A. Bonsteel and party, in cooperation with the Illinois Experiment Station.

Soil Survey of Clinton County, Illinois (491 square miles). By Jay A. Bonsteel and party, in cooperation with the Illinois Experiment Station.

Soil Survey of St. Clair County, Illinois (650 square miles). By George N. Coffey and party, in cooperation with the Illinois Experiment Station.

Soil Survey of Clay County, Illinois (460 square miles). By George N. Coffey and party, in cooperation with the Illinois Experiment Station.

Soil Survey of the Janesville Area, Wisconsin (451 square miles). By Jay A. Bonsteel.

Soil Survey of the Dubuque Area, Iowa (440 square miles). By Elmer O. Fippin.

Soil Survey of Howell County, Missouri (919 square miles). By Elmer O. Fippin and James L. Burgess.

Soil Survey of the Stuttgart Area, Arkansas (251 square miles). By J. E. Lapham.

Soil Survey of the Wichita Area, Kansas (465 square miles). By J. E. Lapham and B. A. Olshausen.

Soil Survey of the Grand Forks Area, North Dakota (314 square miles). By Charles A. Jensen and N. P. Neill.

Soil Survey of the Billings Area, Montana (107 square miles). By Charles A. Jensen and N. P. Neill.

Soil Survey of the Lewiston Area, Idaho (308 square miles). By Louis Mesmer.

Soil Survey of the Walla Walla Area, Washington (201 square miles). By J. Garnett Holmes.

Soil Survey of the Lower Arkansas Valley, Colorado (945 square miles). By Macy H. Lapham and party.

Soil Survey of the Yuma Area, Arizona (99 square miles). By J. Garnett Holmes.

Soil Survey from Arecibo to Ponce, Porto Rico (330 square miles). By Clarence W. Dorsey, Louis Mesner, and Thomas A. Caine.

Field Operations of the Bureau of Soils, .
Chief of Bureau, with accompanying pa
of field parties. Pp. 1310, pls. 3, figs.
1904. Price, $6.35.

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Soil Survey of the Jacksonville Area, Tennessee (100 square miles). By W. Edward Hearn and James L. Burgess.

Soil Survey of the Paris Area, Texas (550 square miles). By Thomas A. Caine and A. E. Kocher.

Soil Survey of Miller County, Arkansas (648 square miles). By J. O. Martin and E. P. Carr.

Soil Survey of the Pikeville Area, Tennessee (440 square miles). By Henry J. Wilder and W. J. Geib.

Soil Survey of Davidson County, Tennessee (501 square miles). By William G. Smith and Hugh H. Bennett.

Soil Survey of Scott County, Kentucky (280 square miles). By R. T. Avon Burke.

Soil Survey of Mason County, Kentucky (225 square miles). By R. T. Avon Burke.

Soil survey of the Ashtabula Area, Ohio (340 square miles). By J. O. Martin and E. P. Carr.

Soil Survey of the Pontiac Area, Michigan (324 square miles). By Henry J. Wilder and W. J. Geib.

Soil Survey of Madison County, Indiana (450 square miles). By R. T. Avon Burke and La Mott Ruhlen.

Soil Survey of Sangamon County, Illinois (866 square miles). By George N. Coffey and party.

Soil Survey of Johnson County, Illinois (340 square miles). By George N. Coffee and party.

Soil Survey of Knox County, Illinois (717 square miles). By George N. Coffee and party.

Soil Survey of Winnebago County, Illinois (526 square miles). By George N. Coffey and party.

Soil Survey of McLean County, Illinois (1,158 square miles). By George N. Coffey and party.

Soil survey of the Viroqua Area, Wisconsin (504 square miles). By William G. Smith.

Soil Survey of the Marshall Area, Minnesota (233 square miles). By Henry J. Wilder.

Soil Survey of Story County, Iowa (576 square miles). By Herbert W. Marean and Grove B. Jones.

Soil Survey of Cerro Gordo County, Iowa (567 square miles). By Herbert W. Marean and Grove B. Jones.

Soil Survey of Shelby County, Missouri (511 square miles). By R. T. Avon Burke and La Mott Ruhlen.

Soil Survey of the Parsons Area, Kansas (398 square miles). By J. A. Drake.

Soil Survey of the Russell Area, Kansas (270 square miles). By A. W. Mangum and J. A. Drake.

Soil Survey of the Grand Island Area, Nebraska (446 square miles). By W. Edward Hearn and James L. Burgess.

Soil Survey of the Stanton Area, Nebraska (323 square miles). By W. Edward Hearn.

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Soil Survey of the Los Angeles Area, California
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